COSEWIC
Assessment and Status Report

on the

Gillman's Goldenrod
Solidago gillmanii

in Canada

ENDANGERED
2019

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

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

COSEWIC. 2019. COSEWIC assessment and status report on the Gillman's Goldenrod *Solidago gillmanii* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. x + 43 pp. (https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry.html).

Production note:
COSEWIC would like to acknowledge Judith Jones for writing the status report on Gillman's Goldenrod, *Solidago gillmanii*, in Canada, prepared under contract with Environment and Climate Change Canada. This report was overseen and edited by Jana Vamosi, Co-chair of the COSEWIC Vascular Plants Specialist Subcommittee.

For additional copies contact:

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

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

Également disponible en français sous le titre Évaluation et Rapport de situation du COSEPAC sur la Verge d'or de Gillman (*Solidago gillmanii*) au Canada.

Cover illustration/photo:
Gillman's Goldenrod — Photo by Judith Jones.

Catalogue No. CW69-14/792-2020E-PDF
ISBN 978-0-660-35209-1

COSEWIC
Assessment Summary

Assessment Summary – November 2019

Common name
Gillman's Goldenrod

Scientific name
Solidago gillmanii

Status
Endangered

Reason for designation
This perennial plant species is a Great Lakes endemic now found in Canada only on one island off the south shore of Manitoulin Island in Lake Huron. The species is threatened by habitat disturbance caused by invasive plants.

Occurrence
Ontario

Status history
Designated Endangered in November 2019.

COSEWIC
Executive Summary

Gillman's Goldenrod
Solidago gillmanii

Wildlife Species Description and Significance

Gillman's Goldenrod has been considered a variety or subspecies of many different goldenrod species. Recent genetic work supports recognition of the taxon as a distinct species called *Solidago gillmanii*. The Latin name is used in this document to prevent confusion with previous entities that have used the common name of Gillman's Goldenrod. *Solidago gillmanii* is a perennial with a relatively large, wand-shaped inflorescence and stalked leaves that decrease noticeably in size going up the stem. The basal leaves have toothed margins. *Solidago gillmanii* is easily mistaken for Hairy Goldenrod and Bog Goldenrod, which can occur in the same habitats.

Distribution

Solidago gillmanii is only found on dunes on the shores of Lake Michigan and Lake Huron. In Canada, *S. gillmanii* currently occurs only on Great Duck Island in northern Lake Huron south of Manitoulin Island. There are two subpopulations 2.5 km apart. *Solidago gillmanii* is common in Michigan on dunes on the Lake Michigan shore but uncommon on Lake Huron. It is present but at risk in Wisconsin and Indiana. The species is reported but unconfirmed in Illinois. A collection from 1976 shows a subpopulation once occurred at Deans Bay on Manitoulin Island but was extirpated prior to 2000. It is unknown why *S. gillmanii* does not occur at any of the more than 30 apparently suitable dune sites across the south shores of Manitoulin and Cockburn islands.

Habitat

Habitat for *S. gillmanii* consists exclusively of open sand dunes with sparse vegetation and patches of bare sand. The vegetation community type of the dune habitat, Little Bluestem – Long-leaved Reed Grass – Great Lakes Wheat Grass Dune Grassland, is considered of provincial conservation concern and ranked imperilled in Ontario. Dune habitats are maintained by dynamic forces (wind, wave-wash, ice movement, changes in lake levels, etc.) that move and pile up sand. In active dunes, these forces keep vegetation sparse and sand loose. Habitat sizes at Desert Point and Horseshoe Bay have remained more or less stable since 2004. Horseshoe Bay contains about 1.65 ha of habitat, while Desert Point contains about 27.3 ha. Habitat quality at Horseshoe Bay is being affected by the spread of the exotic Glandular Baby's Breath.

Biology

Basal rosettes of *S. gillmanii* may occur singly or in a cluster on a very short rhizome. Each cluster is considered one individual although it may have multiple upright flowering stems. While in many other goldenrod species cross-pollination is required for seed set, and seed viability may decrease in a matter of months, there is no information on *S. gillmanii*. Goldenrods have wind-dispersed seeds, but long-distance dispersal (on the order of kilometres) is rare in the Asteraceae. There are many suitable dune habitats on Manitoulin Island within several kilometres of Great Duck Island. It is unknown whether dispersal limitations are involved in the restricted range of *S. gillmanii*.

Population Sizes and Trends

In 2018, there were approximately 5000 mature individuals at Desert Point and 1500 at Horseshoe Bay. Horseshoe Bay has more individuals per unit area, despite being a smaller dune area with denser vegetation cover and much less open sand. No decline in mature individuals has been documented. The Deans Bay subpopulation was extirpated between 1976 and 2000. The magnitude of the loss is unknown but it is presumed unlikely the species was ever abundant there due to the narrowness of the beaches that become submerged at higher lake levels, as well as to beach-clearing activities of adjacent landowners. Rescue is presumed to be unlikely.

Threats and Limiting Factors

Great Duck Island has no residents and no road access, and is a remote locality even for most boaters. A very small amount of recreational use occurs, but in 2018 there was no evidence of camping, erosion from foot traffic, or garbage. The main threats to *S. gillmanii* are invasive species (Glandular Baby's Breath). The limiting factors that naturally affect dune species at some other sites (lack of habitat; lack of natural dune dynamics) do not seem to be affecting *S. gillmanii*. The overall calculated threat level is Low.

Protection, Status and Ranks

In both Wisconsin and Indiana, Gillman's Goldenrod (as *Solidago simplex* var. *gillmanii*) is listed Threatened and ranked imperilled (S2). In Michigan, the level of conservation concern for *S. gillmanii* has not been ranked, but the species apparently does not warrant state listing. In Canada, the species is ranked critically imperilled (S1) in Ontario and nationally (N1). *Solidago gillmanii* is not currently listed at-risk and is not protected by the federal *Species at Risk Act* (SARA) or the Ontario *Endangered Species Act 2007*. The Ontario Provincial Policy Statement restricts alteration of the habitat of rare species and of rare vegetation communities including dunes. However, the restrictions are rarely enforced in the Manitoulin District. Great Duck Island is privately owned as a single parcel.

TECHNICAL SUMMARY

Solidago gillmanii

Gillman's Goldenrod

Verge d'or de Gillman

Gillman Shaashoobaasing (Anishnaabemowin language)

Range of occurrence in Canada: Ontario

Demographic Information

Generation time (usually average age of parents in the population).	Unknown, but probably several years to more than a decade (the range of 5-15 years is used for the purposes of this report)
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	No observed decline in last 18 years but continuing decline projected.
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations].	Unknown but inferred to be small over last 3 generations due to small size of Deans Bay subpopulation
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	Unknown but a reduction inferred; *Some reduction inferred over next 3 generations years due to increase in invasive species. Greater reduction projected if no action is taken.*
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future.	Unknown but a reduction inferred over next 3 generations; *Reductions inferred due to increase in invasive species.*
Are the causes of the decline a. clearly reversible and b. understood and c. ceased?	a. yes b. yes c. no *Answers based on potential decline due to observed threat from invasive species.*
Are there extreme fluctuations in number of mature individuals?	no

Extent and Occupancy Information

Estimated extent of occurrence (EOO) *Actual EOO is 1.7 km^2 which is less than IAO.*	8 km²
Index of area of occupancy (IAO) using a 2x2 grid value	8 km²

Is the population “severely fragmented” i.e., is >50% of its total area of occupancy in habitat patches that are (a) smaller than would be required to support a viable population, and (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a. no b. probably yes *Probably not fragmented in Canada but separated from nearest subpopulations (in Michigan) by large body of water*
Number of “locations” (use plausible range to reflect uncertainty if appropriate)	2-5; *There are 2 subpopulations, with one currently subjected to the threat of an invasive species. It is plausible that the invasive species will arrive at the 2nd subpopulation within three generations but will not have spread throughout this subpopulation within that timeframe.*
Is there an [observed, inferred, or projected] decline in extent of occurrence?	No—last 18 years Yes—between 1976 and 2000; *Possibly, depending on generation time and the time of extirpation of Deans Bay. Observed decline from loss of one subpopulation between 1976 and 2000; no decline last 18 years.*
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	No—last 18 years Yes—between 1976 and 2000; *Observed decline from loss of one subpopulation between 1976 and 2000; no decline observed directly in last 18 years.*
Is there an [observed, inferred, or projected] decline in number of subpopulations?	No—last 18 years Yes—between 1976 and 2000; *Loss of 1 subpopulation prior to 2000.*
Is there an [observed, inferred, or projected] decline in number of “locations”*?	No—last 18 years Yes—between 1976 and 2000; *Deans Bay subpopulation would be a different location from those on Great Duck Island.*
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	Yes; Some decline observed in habitat quality at one site; *Some decline due to invasive species at Horseshoe Bay.*
Are there extreme fluctuations in number of subpopulations?	No
Are there extreme fluctuations in number of “locations”?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

* See Definitions and Abbreviations on COSEWIC website and IUCN (Feb 2014) for more information on this term

Number of Mature Individuals (in each subpopulation)

Subpopulations	N Mature Individuals
Desert Point, Great Duck Island	~5000
Horseshoe Bay, Great Duck Island	~1500
Total	~6500

Quantitative Analysis

Is the probability of extinction in the wild at least [20% within 20 years or 5 generations, or 10% within 100 years]?	N/A but probably no

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

Was a threats calculator completed for this species? Yes.

i. 8.1 Invasive non-native/alien species (Medium-Low)
ii. all others are negligible or outside of assessment time frame

Overall threat impact is calculated as Low

What additional limiting factors are relevant?
Solidago gillmanii is a species adapted to dune habitats and requires high levels of disturbance and consequent reductions in competition from other species

Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada. *Species is common in suitable habitat on Michigan dunes but is restricted by where these occur.*	Secure (S5)
Is immigration known or possible?	No *Long-distance dispersal is presumed to be nearly impossible because the species has not become established (or has not persisted in the case of Deans Bay) on any of the numerous nearby dune sites on Manitoulin Island, which are only a few kilometres from extant subpopulations.*
Would immigrants be adapted to survive in Canada?	Very probably, yes
Is there sufficient habitat for immigrants in Canada?	Yes
Are conditions deteriorating in Canada?	No
Are conditions for the source (i.e., outside) population deteriorating? *Solidago gillmaniii is common at most beaches on the Lake Michigan shore.*	No
Is the Canadian population considered to be a sink?	No
Is rescue from outside populations likely?	No

Data Sensitive Species

Is this a data sensitive species?	No

Status History

COSEWIC Status History: Designated Endangered in November 2019.

Recommended Status and Reasons for Designation:

Recommended Status:	**Alpha-numeric codes:**
Endangered	B1ab(iii)+2ab(iii)
Reasons for designation: This perennial plant species is a Great Lakes endemic now found in Canada only on one island off the south shore of Manitoulin Island in Lake Huron. The species is threatened by habitat disturbance caused by invasive plants.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. Data are lacking to determine the percentage of reduction.
Criterion B (Small Distribution Range and Decline or Fluctuation): Meets Endangered, B1ab(iii)+2ab(iii), with very restricted EOO and IAO, fewer than five locations, and an observed decline in habitat quality.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. Although the threshold for Threatened C1 is met based on small number of individuals, the rates of decline in number of mature individuals is uncertain.
Criterion D (Very Small or Restricted Population): Not applicable.
Criterion E (Quantitative Analysis): Not applicable. Not done.

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS (2019)

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

Environment and Climate Change Canada
Canadian Wildlife Service
Environnement et Changement climatique Canada
Service canadien de la faune
Canada

The Canadian Wildlife Service, Environment and Climate Change Canada, provides full administrative and financial support to the COSEWIC Secretariat.

COSEWIC Status Report

on the

Gillman's Goldenrod

Solidago gillmanii

in Canada

2019

TABLE OF CONTENTS

List of Figures

List of Tables

List of Appendices

WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Names

Scientific name: *Solidago gillmanii* (A. Gray) Steele

Synonyms: Many synonyms. See **Classification and Nomenclature**.

Common Name: Gillman's Goldenrod

Nom commun: Verge d'or de Gillman

Anishnaabe Nooswin Gillman Shaashoobaasing

Family: Asteraceae

Major plant group: Dicot, flowering plant

Variations in spelling have occurred in the published literature. The incorrect epithets *gillmani*, *gilmanii*, and *gillmana* may be found in some synonyms or reports.

Several different taxa have been called Gillman's Goldenrod in the past (see **Classification and Nomenclature**). To prevent confusion, the entity that is the subject of this report will be referred to by its Latin name *Solidago gillmanii*. Latin names will also be used for other species of goldenrods throughout this document. A list of English names corresponding to the Latin names used in the text is given in Appendix 1.

Morphological Description

Solidago gillmanii is a herbaceous perennial plant that may be 30-120 cm tall. Like all goldenrods, it produces tiny yellow flowers clustered into heads shaped like daisies, and the flowers develop into one-seeded fruits (cypselae or achenes) with a ring of bristles (the pappus) at the top. As a member of the *Humiles* subsection of the genus, *S. gillmanii* has resinous glands on the leaves and phyllaries (scales on the outside of the flower heads), flowers in a wand-shaped raceme or panicle, and heads that are not secund (on only one side of the stalk). In addition, it has stalked cauline (stem) leaves, which are present at flowering time and are not triple-nerved (Semple and Cook 2006).

The basal leaves of *S. gillmanii* are 15-30 cm long, spatulate to obovate, with serrate or crenate margins and an acute tip (Figure 1). The cauline leaves are often sharply serrate and decrease very noticeably in size going up the stem (Figure 2). Flowering stems have relatively large heads (compared to other goldenrods) 6-9 mm tall by 5-10 mm wide, consisting of 7-16 pistillate ray florets in the outer whorl and 6-31 bisexual disc florets in the inner head (Semple and Cook 2006). The fruits (cypselae) are dry and seed-like, and sparsely hairy with the hairs pointing upward (antrorse) toward the pappus. In Canada, flowering occurs from late August to early October until below freezing temperatures occur.

Figure 1. Basal leaves of *S. gillmanii* showing the spatulate to ovate shape and the distinctly toothed margins. Photo: Judith Jones.

Figure 2. Upright stems of *S. gillmanii* showing the distinctive way the cauline leaves decrease in size going up the stem and point somewhat upwards. Photo: Judith Jones.

Solidago gillmanii is easily confused with other goldenrods with wand-shaped inflorescences growing in the same habitats, such as large plants of the Lake Huron Goldenrod (*S. hispida* var. *huronensis*), which are glabrous, and with the narrow-leaved plants of the Bog Goldenrod (*S. uliginosa*), which have petiolate leaves that decrease in size going up the stem. *Solidago gillmanii* may be distinguished from *S. hispida* (any

variety) (Figure 3 a, b) by its resinous glands on the phyllaries and petioles, and by its fruits which are slightly to densely hairy, while those of *S. hispida* are usually glabrous (Semple and Cook 2006). In addition, the cauline leaves of *S. gillmanii* are somewhat appressed to the stem and point upwards, whereas those of *S. hispida* tend to spread out at right angles from the stem. *Solidago gillmanii* tends to have many small leaves on the stem under the inflorescence where *S. hispida* has fewer leaves that are more widely spaced apart (Jones pers. obs.).

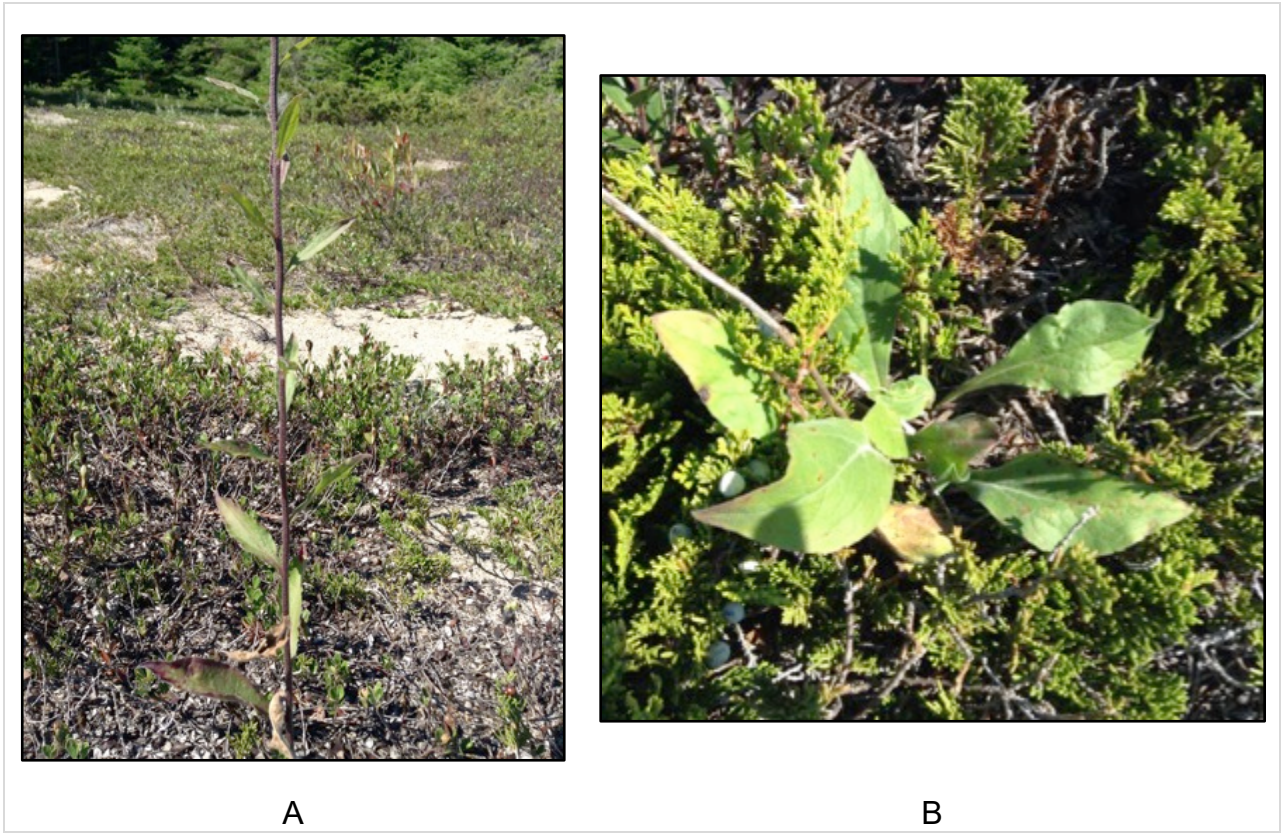

Figure 3. Basal leaves and upright stems of *S. hispida* var. *hispida* for comparison. A. More widely spaced cauline leaves, without stalks, stick out from the hairy or rough stem; B. basal leaves with only faint toothing on the margins. Photo: Judith Jones.

Solidago gillmanii may be distinguished from *S. uliginosa* by basal leaves which do not sheath the stem, whereas those of *S. uliginosa* have long petioles which partially encircle the stem. The leaves of *S. uliginosa* have only small rounded teeth on the margins. Most regional keys (e.g. Semple *et al.* 1999; Reznicek *et al.* 2011) give the habitat of *S. uliginosa* as bogs and many other places on damp ground; however, a narrow-leaved form of this species grows on dunes and beaches (Semple pers. comm. 2018) even on dry sand (Jones pers. obs. 2018).

Solidago gillmanii may also be distinguished from the Ontario Goldenrod (*S. ontarioensis;* formerly *S. simplex* var. *ontarioensis*) by having serrate leaf margins rather than margins only crenate (rounded teeth) or slightly toothed, and by having large, wide leaves (10-42 mm), rather than narrower ones (2-10 mm wide) (Semple and Cook 2006). Other helpful clues are that *S. gillmanii* is a large stature plant found only on sand, while *S. ontarioensis* is a smaller stature plant found only on rocks.

Classification and Nomenclature

Plants fitting the description of *S. gillmanii* above were first collected in 1872 from Lake Michigan dunes at St. Joseph, Michigan, by Henry Gillman, the assistant superintendent of lighthouse construction on the American side of the Great Lakes (Voss 1978). Harvard botanist Asa Gray called the taxon *Solidago humilis* Pursh var. *gillmani* (Gray 1882). In 1911, Edward S. Steele, of the U.S. National Museum Division of Plants described the taxon as a separate species, *S. gillmanii* (A. Gray) (Steele 1911). Historically, species and variety concepts of most vascular plants were mainly defined by similarities of morphology within a group, especially the size and shape of the leaves and inflorescences (Lawrence 1951).

Despite Steele's treatment, until very recently the entity now called *S. gillmanii* was generally considered a variety or subspecies of other goldenrod species. Some previous synonyms noted by Semple and Peirson (2013) include:

Solidago humilis Pursh var. *gillmanii* A. Gray

Solidago virgaurea L. var. *gillmanii* (A. Gray) Porter (1893)

Solidago racemosa Greene var. *gillmanii* (A. Gray) Fernald (1908)

Solidago purshii Pursh var. *gillmanii* (A. Gray) Farwell (1930)

Solidago glutinosa Nutt. ssp. *randii* var. *gillmani* (A. Gray) Cronquist (1947)

Solidago spathulata var. *gillmani* (A. Gray) Gleason (1952)

Solidago simplex Kunth ssp. *randii* var. *gillmanii* (A. Gray) Ringius (Ringius and Semple 1991)

Solidago deamii Fernald

Ringius (1987) divided *S. simplex* into two subspecies, with ssp. *simplex* containing three diploid varieties, and ssp. *randii* containing four tetraploid or hexaploid varieties, including the former var. *gillmanii*, which is tetraploid. Most authors (e.g. Gleason and Cronquist 1991; Voss 1996; Semple *et al.* 1999; Semple and Cook 2006) adopted Ringius's treatment and called the entity *Solidago simplex* ssp. *randii* var. *gillmanii*.

Semple and Peirson (2013) revised the nomenclature of the *S. simplex* complex based on new research (discussed in detail in the next section) which shows that the four varieties within *S. simplex* ssp. *randii* were likely not descended from a single lineage. The authors supported treating the four varieties as separate species, with *S. gillmanii, S. ontarioensis, S. randii* and *S. racemosa* being the oldest correctly applied names.

Semple *et al.* (2016) did a multivariate statistical analysis of 38 traits among three western species of subsection *Humiles* including *S. simplex, S. spathulata*, and *S. glutinosa.* They found *S. simplex* was statistically distinct and endemic to central Mexico, and thus the correct name for former *S. simplex* of northwestern North America should be *S. glutinosa* (the next oldest applied name). Given these taxonomic updates, the taxon *S. gillmanii* cannot be called a variety of *S. simplex.*

A lectotype for *S. gillmanii* was designated (Ringius 1987) from a specimen of a plant cultivated from roots collected on northern Lake Michigan in 1879 (Voss 1996). The original collection by Gillman (isolectotype) is in Gray Herbarium. Other syntypes are there and in the herbarium of the New York Botanical Garden (Semple and Peirson 2013).

Genetics and Basis for the Species Concept

Recently work has been done to clarify phylogeny within subsection *Humiles* and within the *S. simplex* complex. The results provide several reasons for the recognition of *S. gillmanii* as a distinct species. Note that genetic material from the Desert Point subpopulation was included in some of these genetic studies (Peirson *et al.* 2013; Semple pers. comm. 2018).

Peirson *et al.* (2013) analysed chloroplast DNA (cpDNA) from range-wide individuals within subsection *Humiles* to examine the origins and biogeography of the subsection members. Their analyses of ssp. *randii* found 24 haplotypes that did not form a single clade as well as evidence that polyploidy developed multiple times within the *S. simplex* complex. Their results also indicated that the former *S. simplex* complex survived glaciation in multiple refugia in different regions of the continent and that the Great Lakes region was likely colonized multiple times from western populations. Given these differences, the authors conclude that the members of ssp. *randii* (including *S. gillmanii*) should not be treated as a single species.

Peirson *et al.* (2012) used chromosome counts and flow cytometry to create cytotypes for 337 individuals within all five species of the former subsection *Humiles* including all seven former varieties within *S. simplex.* Cytogeographic patterns in *S. simplex* revealed that ssp. *simplex* and ssp. *randii* were cytologically distinct and geographically isolated, and that each is composed of several ecologically, geographically, and morphologically separable subtaxa. The authors then applied criteria that have been used to separate species in other polyploid complexes of *Solidago* to see whether it might be appropriate to recognize the subtaxa within ssp. *randii* as distinct species. Criteria included reproductive isolation, geographic or ecological isolation, phlyogenetic isolation (i.e., do the data show species may have recently evolved from a common ancestor?), and morphological

distinctions. They concluded that *S. gillmanii* warranted recognition as a distinct species as it cannot cross with other former varieties of *S. simplex*, occurs in a very different habitat from the other varieties, and is morphologically distinct.

The phylogenetic data did not rule out the possibility *S. gillmanii* may have had multiple independent origins (not from a single ancestor). However, the authors note that the adaptive pressures to survive in a dune environment may have been a strong enough force to shape an assemblage of lineages into a well-defined species. Given that *S. simplex* is endemic to central Mexico (Semple 2016; Semple *et al.* 2016), the multiple recolonizations from the west, the lack of a single clade for ssp. *randii* (Peirson *et al.* 2013), and reproductive, ecological and morphological distinctiveness comparable to that of other species within *Solidago* (Peirson *et al.* 2012), there is solid evidence to support recognition of *S. gillmanii* as a species. *Solidago* is a very large genus in which, until recently, phylogenetic relationships have been very confusing. *S. gillmanii* is not unique in being a new species recognized through taxonomic changes within this genus.

Population Spatial Structure and Variability

In Canada, *S. gillmanii* occurs on a remote island in Lake Huron, with approximately 55 km of open water separating the Canadian subpopulations from the next nearest population in Michigan. Thus, the Canadian population is geographically isolated, and the likelihood of genetic exchange from any other population is extremely low. This is discussed further in **Rescue Effect**. No genetic work has been done specifically on population structure in Canada.

Designatable Units

Only one designatable unit (DU) is applied, based on only two subpopulations in Canada, geographically very close together, in one location. It is highly unlikely these subpopulations would be different genetic entities. The extirpated subpopulation at Deans Bay would also belong to the same DU, as would any other subpopulation discovered on mainland Manitoulin Island.

Special Significance

Goldenrods, in general, have broad medicinal value. Historically, medicines were prepared from some of the other goldenrod species found in the Manitoulin region (such as *S. canadensis, S. juncea,* and *S. uliginosa*) and used to treat sore throats, fevers, boils, burns, and several other ailments (Vogel 1970; Erichsen-Brown 1979; Moerman 1998). No medicinal use has been reported specifically for *S. gillmanii* under this name or its synonyms.

Two patents have been registered in the U.S. for fractionation processes to create medicinal products from goldenrods (Nagy *et al.* 2009a, b). No one species of *Solidago* is indicated as the source. Instead, a long list of species is provided, perhaps to allow the patent holders to try any goldenrod species. *Solidago gillmanii*, almost all of its synonyms, and the names of several other rare and at-risk goldenrods are also included.

No Aboriginal Traditional Knowledge (ATK) has been found for *S. gillmanii*. As part of the Species at Risk Program at Wiikwemkoong Unceded Territory on Manitoulin Island, Jones and Flamand searched for ATK about plants in the local area (Wiikwemkoong Department of Lands and Natural Resources undated-a, b, c; Jones and Flamand unpublished data 2007-2018). They found no ATK in the region for any goldenrod species although there is a name for goldenrod (*shaashoobaasing*) in the Anishnaabemowin language.

DISTRIBUTION

Global Range

Solidago gillmanii is a Great Lakes endemic only found on sand dunes on the shores of Lake Michigan and Lake Huron (Figure 4). The species (as *S. simplex* ssp. *randii* var. *gillmanii*) is reported from Wisconsin, Michigan, Indiana, and Ontario (NatureServe 2018). In Wisconsin, it occurs in Door and Sheboygan counties, and in Indiana it occurs in Lake, Porter, and La Porte counties. All subpopulations in Wisconsin and Indiana are on Lake Michigan.

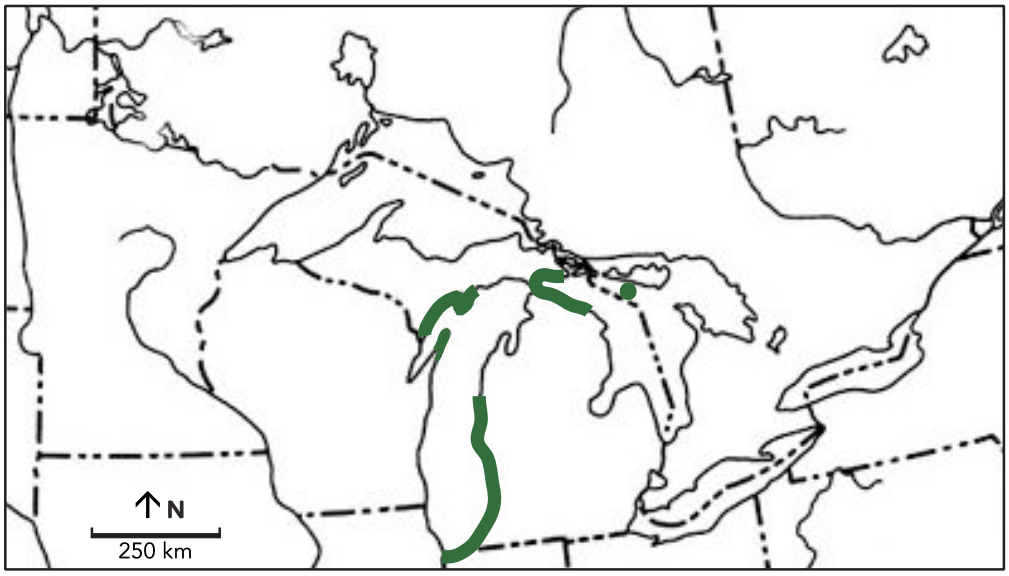

Figure 4. Current global range of *S. gillmanii* (shown in green). Sources: Reznicek *et al.* (2011), Indiana DNR (2016), Wisconsin DNR (2017), Semple (2018), and Reznicek (pers. com. 2018).

In Michigan, *S. gillmanii* is common and characteristic of dunes on Lake Michigan and is present in most counties along the western shoreline of the state (Reznicek pers. comm. 2018; Semple pers. comm. 2018). It is also present on several islands in both Lake Michigan and Lake Huron, but there are only a few records from the mainland Lake Huron shoreline—all from the four counties bordering the straits of Mackinac (University of Michigan Herbarium unpublished data 2018).

In Illinois, *S. gillmanii* was historically reported "in the vicinity of Chicago", based on two undated specimens in Field Museum (Consortium of Midwest Herbaria 2018). However, it is possible these collections came from the Indiana Dunes (Reznicek pers. comm. 2019). The North American Plant Atlas (Kartesz 2015) and the database of the Illinois Natural History Survey (Spryeas *et al.* 2017) do not show the species or any of its synonyms as present in Illinois. The plants database of the USDA Natural Resources Conservation Service has records of the species being present in Illinois (USDA 2019) but there is no coding to show whether the records are current or historical. NatureServe shows the status of the species in Illinois as reported but unconfirmed (SNA) (Frances pers. comm. 2019).

Canadian Range

Figure 5 shows the Canadian range of *S. gillmanii* as well as other sites[2] with apparently suitable dune habitat in the Manitoulin Island region. In Canada, the species is restricted to two sites on Great Duck Island off the south shore of Manitoulin Island in northern Lake Huron. The species was also reported historically from a third site in the same region at Deans Bay on Manitoulin Island (Semple *et al.* 1999; Morton and Venn unpublished data 2010; Semple pers. comm. 2018). Recent fieldwork for this report reconfirmed presence at both sites on Great Duck Island but did not find *S. gillmanii* present at Deans Bay despite extensive searching.

A number of factors may have led to the restricted geographic range of *S. gillmanii*. Phylogenetic and biogeographic studies of the *Solidago simplex* complex have shown that the Great Lakes region was likely colonized multiple times from the west by diploid ancestors (Peirson *et al.* 2013). Given multiple events in which the species reached the Great Lakes region, it may be that the current locality on Great Duck Island is simply as far east as dispersal events were able to reach.

[2] Site refers to a physical place where *S. gillmanii* occurs or has occurred, or where there is suitable habitat. Subpopulation (an element occurrence in NatureServe (2004)) in the case of *S. gillmanii* refers to all individuals that are within 1 km of another *S. gillmanii* individual and separated from others by ≥ 1 km of persistently unsuitable habitat. Population refers to the sum total of all *S. gillmanii* plants in Canada. Location refers to a geographically or ecologically distinct area in which subpopulations of *S. gillmanii* may be subject to the same threats and/or management.

Figure 5. Current range of *S. gillmanii* in Canada. Extant subpopulations (yellow dots) are present at Horseshoe Bay and Desert Point, Great Duck Island. Numbers correspond to sites listed in Table 1 and show suitable dune habitats surveyed for *S. gillmanii* in 2018 (grey dots). "U" denotes dune sites not surveyed. Number 17 (orange dot) shows the site of the extirpated subpopulation at Deans Bay. Source: Judith Jones.

Studies also show that polyploidy formed multiple times and that speciation in *S. simplex* may have occurred on contemporary ecological time scales, possibly since the last glaciation of the Great Lakes (Peirson *et al.* 2012). This brings up the possibility that *S. gillmanii* in Canada may have become a distinct species in situ and may not have dispersed to its current locality.

The 1976 collection of *S. gillmanii* from Deans Bay shows that the species was once present on Manitoulin Island. It is puzzling that *S. gillmanii* has never been found at any of the much larger, more diverse, or more frequently visited dune sites elsewhere on the south shore of Manitoulin Island, such as Carter Bay, Providence Bay, or Dominion Bay, or at smaller dunes on remote parts of the Manitoulin shoreline closer to Great Duck Island, such as at Black Point, Carroll Wood Bay, or Misery Bay. Especially remarkable is the fact that *S. gillmanii* is not present on dunes on Western Duck Island, just 9 km north-northwest of Desert Point and 10 km due north of Horseshoe Bay. The identification of the Deans Bay specimen has been determined by J.C. Semple, so the identity of the plant is not in error, and it seems unlikely that the wrong label data could have been put on the specimen. If there is no error, then it is possible that a random, long-distance dispersal event occurred, although it is unknown why it has not occurred again or to any other site. Alternatively, perhaps *S. gillmanii* once had a greater geographic range in a post-glacial time frame, but all sites except those on Duck Island were extirpated. This possibility seems very unlikely given the fact that there are many high-quality dune sites in the Manitoulin region where other highly geographically restricted species remain present.

One additional factor that might be involved in the restricted range could be a lack of traits to compete with similar dune species. For example, perhaps *S. gillmanii* is out-competed by other members of subsection *Humiles* such as the much more common *S. hispida*. Other *Humiles* species and *S. gillmanii* have not been observed to grow together (Jones pers. obs. 2018).

See further discussion of dispersal in **Biology** and in **Rescue Effect**.

Extent of Occurrence and Area of Occupancy

The actual mapped extent of occurrence (EOO) for *S. gillmanii* in Canada is 1.7 km^2 (170 hectares), based on the area of a polygon with no concave sides containing all individuals and all occupied habitat. The EOO is very small because there are only two subpopulations in Canada, and they are only 2.5 km apart at their closest points. COSEWIC guidelines state that if extent of occurrence (EOO) is less that the index of area of occupancy (below), the EOO should be changed to make it equal to IAO to ensure consistency with the definition of IAO as an area within EOO. Therefore, the EOO for this species is 8 km^2.

The index of area of occupancy (IAO) for *S. gillmanii* in Canada is 8 km^2 based on 2 km x 2 km grid squares or 29 hectares in total habitat area. The Horseshoe Bay subpopulation falls in one 2 x 2 grid square, and the actual habitat area is 1.65 ha. The Desert Point subpopulation falls in one 2 x 2 square, and the actual habitat area is 27.3 ha. Area calculations were made from habitat polygons drawn on satellite imagery with area calculated by online software (Ontario Ministry of Natural Resources and Forestry 2018).

Search Effort

In 2018, 20 sites with suitable dune habitat on the south shores of Manitoulin Island and Cockburn Island, as well as on the Duck Islands, were surveyed to search for *S. gillmanii* (Table 1). Surveys were done in late August to early September during the bloom period of *S. gillmanii* and many other *Solidago* species to make identification easier. A few sites were re-surveyed in October because some collected material was lost. Goldenrod plants in flower and fruit were still present in October. A total of 21.25 hours was spent surveying.

Table 1. List of sites surveyed in 2018, presence/absence of *S. gillmanii*, and search effort. Sites in bold font have *S. gillmanii* present. Sites where *S. gillmanii* is not present are listed geographically from west to east as shown in Figure 5. All sites are on Manitoulin Island unless noted.

Site #	Site Name	2018 date	*Solidago gillmanii* present?	Hours on site
1	**Desert Point, Great Duck Island**	September 7	**Y**	1.5
2	**Horseshoe Bay, Great Duck Island**	September 7	**Y**	1.0
3	Wagosh Bay, Cockburn Island	September 4	N	1.25 x 2 people
4	Doc Hewson Bay, Cockburn Island	September 3	N	0.75
5	Sand Bay, Cockburn Island	September 3	N	0.5
6	West Belanger Bay	August 21	N	0.5
7	Western Duck Island	September 7	N	1.0
8	Burnt Island Harbour	August 31	N	0.5
9	Christina Bay	August 31	N	0.5
10	Sand Bay	September 6	N	0.5 x 2 people
11	Murphy Harbour	August 22	N	0.25
12	Burpee Beach (E of Murphy Harbour)	August 22 October 17	N	0.25 0.75
13	Taskerville (E of Gatacre Point)	August 24 October 17	N	1.0
14	Portage Bay	October 17	N	0.5
15	Shrigley Bay	September 6	N	0.5 x 2 people
16	Dominion Bay	September 5	N	0.5
17	Deans Bay	September 6 September 7 October 17	N N N	1.25 x 2 people 0.5 0.75
18	Providence Bay	September 7	N	0.5
19	Timber Bay	September 15	N	1.0
20	Carter Bay	September 20	N	1.0 x 2 people
Totals: 20 sites visited; 21.25 person-hours of search effort				

To determine survey sites, Jones compiled all Canadian records of *S. simplex* of any species or subspecies (Morton and Venn 1984, 2000; Semple *et al.* 1999; Morton and Venn unpublished data 2010; Brouillet pers. comm. 2018; Herbarium Marie-Victorin (MT) unpublished data 2018; Natural Heritage Information Centre 2018; Semple pers. comm. 2018) to see whether there might be any other records that would now be reclassified as *S. gillmanii*. However, almost all of the existing records would now be classified as *S. ontarioensis* based on the reasoning that *S. ontarioensis* occurs only on limestone bedrock and rocky shores, while *S. gillmanii* is restricted to sand dunes. Thus, if a record for *S. simplex* came from an area where the shoreline is not sandy, the species was probably *S. ontarioensis.*

This background analysis showed that the only previously reported Canadian records of *S. simplex* that had been determined to be *S. gillmanii* were from Great Duck Island and Deans Bay on Manitoulin Island. This agreed with the sites reported by Semple *et al.*

(1999). Prior to 2018 fieldwork, the most recent collections from both places were from 1976. Three collections of *S. simplex* by Morton and Venn on Manitoulin Island came from places that have both sand and limestone bedrock. Thus, it was not known which species was collected. The actual specimens for these three records could not be located, so these sites were prioritized for field surveys.

During survey work, hundreds of individual goldenrods were observed and some were collected or photographed for closer examination, especially individuals of *S. hispida* var. *huronensis* and the narrow-leaf form of *S. uliginosa*. Eight specimens were sent to J.C. Semple for expert determination.

Between 2000 and 2006 Jones visited all major dune sites on the Canadian side of Lake Huron (Jones 2001-2006) to search for and collect data on Pitcher's Thistle (*Cirsium pitcheri*), a species assessed as Special Concern (COSEWIC 2010a) which grows in the same habitat as *S. gillmanii*. A list of vascular plant species present was compiled for every site (Jones unpublished data 2001-2006). Standardized monitoring of Pitcher's Thistle including a documentation and scoring of threats to the dune habitat has been conducted at sites in the Manitoulin Region since 2004 (Parks Canada Agency unpublished data 2004-2018). As part of the above work, Jones visited Great Duck Island in 2001, 2003, 2004, 2008, 2012, 2016, 2017, and 2018. Data collected show that *S. gillmanii* has been present at the two current sites and absent from all other sites including Deans Bay since at least 2000.

HABITAT

Habitat Requirements

Habitat for *S. gillmanii* consists exclusively of open sand dunes with sparse vegetation and patches of bare sand (Figures 6 and 7). The vegetation usually has distinct zones. On the foredune nearest the lake, the vegetation may be dominated by dune grasses such as Marram Grass (*Ammophila breviligulata*), Giant Sand Reed (*Sporobolus rigidus* var. *magnus*), and Great Lakes Wheat Grass (*Elymus lanceolatus* ssp. *psammophilus*). In the mid-beach, the vegetation is usually dominated by creeping shrubs such as Sand Cherry (*Prunus pumila* var. *depressa*), Creeping Juniper (*Juniperus horizontalis*), and Common Bearberry (*Arctostaphylos uva-ursi*). Farthest from the water, where the sand has been stabilized for a longer time and woody plants have become established, the vegetation is dominated by larger shrubs such as Common Juniper (*Juniperus communis*) and small trees such as Balsam Poplar (*Populus balsamifera*), White Spruce (*Picea glauca*), and Tamarack (*Larix laricina*) (Jones unpublished data and pers. obs. 2000-2018).

Solidago gillmanii occurs throughout the dunes in all the above zones, from a few metres from the water back to the tree line inland of the habitat. In the large dunes at Desert Point, *S. gillmanii* occurs 350 m or more from the water. At Horseshoe Bay, it occurs as far as 80 m or more from the water. At the latter site in 2018, *S. gillmanii* was especially abundant and blooming heavily right along the bottom edge of the foredune, just beyond

the wet sand (Jones pers. obs. 2018). It is possible that disturbance from recent wave-wash or storm surge may have somehow improved growing conditions for this species, perhaps by removing some competing vegetation or by providing increased moisture. At Desert Point, the front of the foredune is extremely steep and densely grass-covered, and *S. gillmanii* was not present until the back side of the foredunes.

The vegetation community that contains suitable habitat is classified as Little Bluestem – Long-leaved Reed Grass – Great Lakes Wheat Grass Dune Grassland SDO1-2 (Lee *et al.* 1998). This community is of provincial conservation concern and is ranked imperilled in Ontario or S2 (Natural Heritage Information Centre 2018). Appendix 2 gives a list of plant species found in the habitat of *S. gillmanii*.

Dune habitats are maintained by dynamic forces that move sand, such as wind, wave-wash, ice movement, and changes in lake levels (Albert 2000; Maun 2009). These forces maintain open sand conditions and prevent trees from becoming established for the long term (Dech *et al.* 2005; Maun 2009). Extreme conditions of wind, heat, light, drought and other climatic factors also prevent many common plant species from becoming established. Dune dynamics cause the build-up of mounds, burial of vegetation, exposure of roots, and blowouts. Plants that require habitat with open, loose sand face a trade-off in the risk of burial or blow out.

Fluctuating water levels in Lake Huron also play a major role in creation and maintenance of dune habitat. Water levels in Lake Huron naturally cycle from high to low over approximately 30 years, with 120 - 160 year extremes (Quinn and Sellinger 2006; Wilcox *et al.* 2007). At high levels, lake water submerges portions of beach and the wave-wash/storm-surge zone creates natural disturbance which may wipe out existing vegetation and move sand around. However, when the water recedes again, the newly exposed sand becomes available habitat and the vegetation has time to grow there again (Jones unpublished data 2000-2018). Thus, dune habitats also naturally fluctuate slightly in size. As well, periodically, some individual plants growing close to the water may get destroyed by the very factors they require to maintain the habitat.

If dunes become densely vegetated, light human disturbance (such as light foot traffic) is sometimes the only force maintaining sparse conditions and creating patches of open sand (Jones unpublished data 2000-2018) and thus might be somewhat beneficial in certain situations. However, in general, high quality habitat is maintained by natural disturbance dynamics and has little additional disturbance from human activities.

A great deal of apparently suitable habitat is available for *S. gillmanii* in the Manitoulin region. Along the south shore of Manitoulin Island and Cockburn Island, and on Western Duck Island, there are more than 30 dune and beach systems with vegetation and associate species similar to the occupied habitats on Great Duck Island (Parks Canada Agency 2011; COSEWIC 2015; Jones unpublished data). However, the species has not been found in any of these places.

Habitat Trends

During periods of low natural disturbance (such as during low lake levels), the inland parts of dunes and beaches eventually become densely vegetated due to natural succession. When all the bare sand becomes covered, habitat suitability for *S. gillmanii* is much reduced. At Horseshoe Bay, the dunes are densely vegetated, and there is little open sand (Figure 7). *Solidago gillmanii* is still currently found throughout the habitat but is more abundant in the lakeward parts of the habitat where there is the most active sand. It is unknown whether the increasing cover of vegetation is causing a decline in numbers of *S. gillmanii* at this site. At Desert Point, some areas are well vegetated, but there are many very large, bare areas (Figure 6).

Figure 6. Habitat of *S. gillmanii* at Desert Point, Great Duck Island. Photo: Judith Jones.

Figure 7. Habitat of *S. gillmanii* at Horseshoe Bay, Great Duck Island. Photo: Judith Jones.

The area of the overall dune habitats at Desert Point and Horseshoe Bay have remained more or less stable since at least 2003, based on habitat boundaries drawn for Pitcher's Thistle (Jones unpublished data 2003) and anecdotal monitoring data (Parks Canada Agency unpublished data 2004-2018) as well as observations of satellite imagery. Based on polygons drawn on satellite imagery, Horseshoe Bay contains about 1.65 ha of habitat, while Desert Point contains about 27.3 ha for a total of about 29 ha. The amount of wet sand area has been slightly reduced in the last two years due to higher lake levels, but so far little vegetation has been lost at either site (Jones pers. obs. 2004-2018).

Habitat quality at Horseshoe Bay is being affected by the exotic plant Glandular Baby's Breath (*Gypsophila scorzonerifolia*). This species is able to compete for the sparsely vegetated spots that would be used by *S. gillmanii* and has very long fibrous roots that stabilize sand and allow other vegetation to get established and fill in. The level of threat to the habitat from Glandular Baby's Breath was scored in 2008, 2016, 2017, and 2018 (Parks Canada Agency unpublished data 2004-2018). In this monitoring system, the threat from any invasives (in this case only Baby's Breath) is scored from 0 to 3, where 0 is no threat, 1 is an occasional and local presence, 2 is an abundant and widespread presence, and 3 is a

dominant and/or heavy presence. In all four years, the threat was scored as 2, but given the broadness of the categories, the scoring does not seem to have detected change. However, written comment fields show that in 2008 Glandular Baby's Breath was "mainly impacting the mid-dunes", while in 2016 it was "heavy over ~2/3 of the back dunes", and in 2018 "the habitat is becoming crowded with Baby's Breath". Thus, habitat quality appears to have been reduced as the invasive species has spread throughout the site.

Intact, apparently suitable habitat still exists at Deans Bay even though no *S. gillmanii* is present. The habitat at Deans Bay consists of a series of narrow beaches, most of which have had cottages present since the mid-1960s (Jones pers. obs.) and thus have received varying levels of human disturbance. Some adjacent landowners occasionally clear the beach of vegetation using machinery. Although this completely destroys the habitat for a time, it does not seem to prevent native dune species from recolonizing the sand (over a number of years) from surrounding undamaged areas. The invasive European Common Reed (*Phragmites australis* ssp. *australis*) was also present for a time at Deans Bay, likely brought in by machinery. The invasive was present until control work and higher lake levels eliminated it in 2017 (Manitoulin Phragmites Project 2017, 2018). Approximately 1.9 ha of apparently suitable habitat is currently present at Deans Bay (based on polygons drawn on satellite imagery). It is unknown why the species is no longer present there.

BIOLOGY

The information provided here comes from a variety of sources about goldenrods, especially Semple *et al.* (1999), Semple and Cook (2006), and Semple (2018). Some information comes from unpublished personal observations of Jones during fieldwork in 2018.

Solidago gillmaniii is a perennial plant that grows as a basal rosette and eventually produces an upright stem supporting flowers and fruit. Rosettes may be single or in a cluster of approximately 2-12 basal rosettes connected by a very short stout rhizome or caudex. Clusters are distinct from each other and are not interconnected by longer rhizomes. Therefore, each cluster is considered one individual although it may have multiple flowering stems. It is assumed that larger clusters with more rosettes generally are older individuals.

Life Cycle and Reproduction

Based on the presence of single sterile rosettes as well as the presence of larger clusters where all rosettes are sterile (Jones pers. obs.), plants may be sterile for one to several years before flowering, and older plants may not flower every year. The average age of plants at maturity, the trigger for flowering (whether plant size, age, climatic factors, etc.), the age at first flowering, and the average life span are unknown. Some other goldenrod species, such as *S. houghtonii*, and *S. speciosa* normally do not flower in consecutive years and are known to live for several decades (COSEWIC 2010b; Jolls and Tolley undated). Generation time for *S. gillmanii* is unknown but is likely between five and

fifteen years, based on the time it might take to form larger clusters. *Solidago gillmanii* reproduces mainly by seed and does not form larger colonies or clones.

Most goldenrods are self-incompatible and require cross-pollination for successful seed set (Werner *et al.* 1980; Gross and Werner 1983; Buchele *et al.* 1992). Presumably this is also the case with *S. gillmanii*. It is possible that seed viability or germinability could be limited. Meyer and Schmid (1999) found survivorship and germinability of seeds of *S. altissima* in the soil decreased rapidly in the first three months after dispersal. Jolls and Tolley (undated) found germinability in seeds of *S. houghtonii* declined significantly after 8-15 months.

Physiology and Adaptability

As a species completely restricted to dunes, *S. gillmanii* must be adapted to living on sand and presumably is able to withstand shifting substrate, abrasion from blowing sand, high levels of light, heat, wind, etc. Many other dune species have obvious adaptations to these conditions, such as a low, creeping habit as seen in Common Bearberry, Sand Cherry, or Creeping Juniper; a layer of whitish hairs on the leaf or plant surface as seen in Pitcher's Thistle, Great Lakes Wheat Grass, and Field Wormwood (*Artemisia campestris*); or leathery leaves as seen in Bearberry and Buffaloberry (*Shepherdia canadensis*). According to Peirson *et al.* (2012) *S. gillmanii* possesses long vertical rhizomes that allow it to withstand sand burial.

Dispersal and Migration

It is unknown whether dispersal restricts the distribution of *S. gillmanii* in Canada to Great Duck Island. In general, *Solidago* species have tiny, dry, single-seeded fruits (achenes) that are mainly wind-dispersed, with the bristles at the top of the fruits acting to catch the wind. The maximum distance that wind-blown *Solidago* fruits can travel is unknown. According to Soons *et al.* (2004), it is hard to predict wind dispersal distances because they depend on a number of variable factors such as wind speed, weather conditions and humidity, height of the inflorescence, plume-loading (the ratio of the falling seed's mass to its area), and the height of the surrounding vegetation.

Distances fruits travel by wind dispersal may be less than is generally assumed. Tackenberg *et al.* (2003) studied the wind dispersal potential of 335 grassland species with a variety of adaptations presumed to aid in wind dispersal. They found that none of the species in the study reached dispersal distances of 100 m. They also found that some long-distance dispersal[3] does occur in extreme weather conditions, but that in open, flat landscapes this happened very rarely. Sheldon and Burrows (1973) found dispersal in the Aster Family is most favourable in fair weather with low humidity which opens and stiffens the bristles on the fruits, but that in such conditions, wind speed is usually low. They concluded that in most cases, long-distance dispersal in the Aster Family is prevented

[3] Long-distance dispersal (LDD) in this document generally refers to movement of fruits beyond habitat boundaries potentially far enough to cross unsuitable habitat to reach new suitable habitat (Nathan *et al.* 2008). In the case of *S. gillmanii*, LDD would be at least 9 km or more, which is the distance to the closest unoccupied suitable dune habitat.

unless convection currents can carry fruits high up in the air. This would certainly be needed for a fruit to be blown from Great Duck Island to the next nearest land sites.

The height of the plant as well as the height of the surrounding vegetation may be a much better indicator of potential dispersal distance (Soons *et al.* 2004; Thompson *et al.* 2011), although seed mass may play a role because once plant height is accounted for, small-seeded species may disperse farther than large-seeded species (Thompson *et al.* 2011). These studies seem to indicate that *S. gillmanii* should have substantial long-distance dispersal potential, being a small-seeded species with tall fruiting stems among shorter vegetation. However, it is possible that dispersing fruits only travel relatively short distances within the habitat but do not travel beyond the habitat to places off Great Duck Island.

There may be other unknown mechanisms that might occasionally cause long-distance dispersal (Higgins 2003). For example, some species of *Solidago* are occasionally dispersed by birds. Czarnecka *et al.* (2012) found germinable seeds of *S. gigantea* in droppings of the Eurasian Blackbird (*Turdus merula*). Small flocks of migrant birds were present at Great Duck Island on September 7, 2018 (Jones pers. obs.) but these would not likely be heading back north to other dune sites on this date. In the spring, it is unknown whether seeds would still be present for consumption by north-bound migrants. Other possibilities might include dispersal by water because many wind-dispersed seeds are able to float for up to a week (Carthey *et al.* 2016). The likelihood of floating seeds of *S. gillmanii* arriving at other suitable dune sites is unknown, but given the large distances (9 km to Western Duck Island; 16 km to Manitoulin Island) and active water involved, it may be fairly low.

Interspecific Interactions

All goldenrods produce heavy, sticky pollen which evolved to be carried by insects and thus cannot blow in the wind or cause hay fever as is commonly believed. Insects visit goldenrods to feed on nectar and pollen, but some also eat leaves or stems without providing a benefit to the plant. Insect vectors for goldenrod pollen include bees, wasps, flies, moths, and butterflies (Semple *et al.* 1999).

No data exist on pollinators specific to *S. gillmanii*, but during fieldwork in September of 2018, hover flies (family Syrphidae) were abundant and visiting goldenrods of all species at both sites on Great Duck Island (Jones pers. obs. 2018). These hover flies were identified as species in the genus *Eristalis* (Locke pers. comm. 2018). A study of *S. houghtonii* (Jolls and Tolley undated) at Sturgeon Bay dunes in Michigan (where it blooms in the same time period as *S. gillmanii*) found that plants received a range of potential insect pollinators, including bees, moths, and beetles. However, experiments comparing artificial hand-pollination to open, wild pollination showed successful sexual reproduction was infrequent in the wild and likely limited by pollen transfer.

Solidago gillmanii flowers relatively late in the growing season, blooming from late August through mid-October (Jones pers. obs. 2018). It might be speculated that there may be some years where cold weather prevents successful pollination due to a lack of insects. However, Gross and Werner (1983) found that seed set was actually greater in later flowering clones of several *Solidago* species, presumably because pollinators had fewer other species to visit and were more restricted to *Solidago*. Thus, it is possible that late flowering of *S. gillmanii* actually confers some benefit.

Some herbivory occurs on *S. gillmanii*. During fieldwork, many plants at Desert Point had cauline leaves that had been partially eaten by insects (Jones pers. obs. 2018).

Solidago gillmanii occurs in the same habitat with the provincially rare dune species Golden Puccoon (*Lithospermum caroliniense*), which in the Manitoulin region is only found on dunes on the Duck Islands. It also occurs with Giant Sand Reed, which does not occur anywhere on Manitoulin Island although it does occur on the southwestern-most shoreline of Cockburn Island. Perhaps in the future, the origins of the ranges of these similarly geographically restricted species may be clarified and may shed light on the restriction of *S. gillmanii* to Great Duck Island.

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

Field surveys were done in September and October of 2018 during the bloom period of *S. gillmanii* and many other goldenrod species. Twenty dune and beach sites on the south shore of Manitoulin Island, Cockburn Island, and the Duck Islands were searched. These included: all sites with sand and proximal records of *S. simplex* (any species); all of the largest and medium-sized dunes; and almost all of the remote sand beaches nearest to Great Duck Island. Only a few suitable areas were not surveyed, including the beaches east of Black Point, east and west of Misery Bay, and Sand Bay (Manitoulin Island). Total survey effort was approximately 21.25 person-hours.

At the first few survey sites, all goldenrods with wand-shaped inflorescences were checked closely, but it quickly became easy to rule out *S. hispida* and most other wand-shaped species from a distance. However, goldenrods hybridize and hybrids may have abnormal characteristics, and there are also some species that have forms that are not listed in commonly-used keys to plants of the Great Lakes region. At three sites, there were narrow-leaved goldenrods with wand-shaped inflorescences that appeared to be the narrow-leaved, dune form of *S. uliginosa*. Although these were not good matches for the characteristics of *S. gillmanii*, examples were collected in case the identification as *S. uliginosa* proved to be incorrect. These collections were sent for expert determination and confirmed as *S. uliginosa,* and five other collections were confirmed as aberrant *S. hispida*; none were *S. gillmanii* (Semple pers. comm. 2018).

At Desert Point, abundance was estimated by walking a transect on a compass bearing across the widest part of the habitat (from the water to the forest) to take in the greatest number of plants and largest variation of abundance. The number of clusters of plants was counted in a swath approximately 20 m wide, which was the distance in which it was possible to discriminate sterile rosettes of *S. gillmanii* from those of other species. The transect polygons were plotted with GoogleEarth Pro (2013) and the area was calculated by that software. The number of plants per unit area surveyed was then multiplied by the total area of the habitat since areas of high abundance and low abundance were fairly evenly distributed throughout the entire habitat.

At Horseshoe Bay, a much smaller site, an actual count of individuals was made over approximately one quarter of the habitat and that number was multiplied by four. This quarter was determined roughly by eye, and included areas of both high and low abundance.

In the initial survey of Deans Bay, no *S. gillmanii* was found. The site was surveyed a second time to double check the site because of the presumed extirpation. This was done after surveys on Great Duck Island confirmed Jones's (2018) search image and to have a second look at the narrow-leaved, dune form of *S. uliginosa*, which was present. The area was surveyed a third time after further communications and an exchange of photos of the dune form of *S. uliginosa* with J.C. Semple (pers. comm. 2018). This level of caution was taken at Deans Bay because the species was formerly present there, and at the other three sites because the dune form of *S. uliginosa* was not so familiar to Jones (Jones pers. comm. 2019).

Abundance

The estimated abundance at Desert Point was approximately 295 individuals per hectare. The entire dune area is approximately 27.3 ha but within this area there are unsuitable wet areas, a few large blocks of trees, and some unoccupied shrubby dune near the forest. These areas were subtracted from total habitat area. Occupied area used to calculate abundance was 17 ha (based on polygons drawn on GoogleEarth), resulting in approximately 5000 mature individuals at Desert Point.

The estimated abundance at Horseshoe Bay was approximately 400 individuals in one quarter of the habitat. However, abundance was somewhat lower near the forest, so the estimate was revised downwards to a total of approximately 1500 individuals at Horseshoe Bay. Given the size of these habitats, the site at Horseshoe Bay is more densely populated with more individuals per unit area, despite being more heavily vegetated and having much less open sand. Because mature individuals can be sterile in some years and no work was done to search specifically for first year seedlings which might be more difficult to spot, all individuals counted are assumed to be mature.

NatureServe (2018) states that *S. simplex* var. *gillmanii* typically occurs in populations of fewer than 100 - 200 individuals with the plants scattered and patchy across the habitat. By contrast, the Canadian subpopulations appear to have more individuals distributed

throughout the entire habitat, although in both subpopulations there was slightly greater abundance on the foredunes (Jones pers. obs. 2018).

Fluctuations and Trends

No data are available to determine trends for the two individual subpopulations as there have been no previous estimates of abundance. However, the species has been informally observed as common at both sites on Great Duck Island in seven visits to the sites since 2000 (Jones unpublished data 2000-2018) and no major changes to the habitats have been observed (Parks Canada unpublished data 2004-2018), so it is inferred that abundance has likely been approximately stable in both subpopulations. This species has not been observed to undergo extreme fluctuations in abundance or distribution (Jones pers. obs. 2000-2018) and as a perennial presumed to live from roughly five to 15 years, is unlikely to undergo such fluctuations. Other perennial goldenrods, such as *S. houghtonii*, *S. speciosa*, and *S. ridellii* are not reported to undergo extreme fluctuations (COSEWIC 2010b; Environment Canada 2015; Government of Canada 2016).

The magnitude of the loss of the Deans Bay subpopulation is unknown but presumed to be small. It is unknown whether the species was ever abundant or widespread there. The species has not been observed there or named in plant lists from the site since 2000 (Jones unpublished data), so it is presumed the decline and loss must have occurred between the collection record of 1976 and Jones's first site visit in late 2000. It is possible the species was extirpated during the extreme high lake levels of the mid-1980s when these narrow beaches were very small and subject to a lot of wave wash. Some parts of the Deans Bay beaches are periodically cleared of vegetation by adjacent landowners, so it is possible that when the species was present, it may not have been highly abundant. Given its presumed small size, the loss of the Deans Bay subpopulation may not represent a large decline in terms of mature individuals.

Rescue Effect

Because the Canadian population is geographically isolated, and the likelihood of genetic exchange from any other population is extremely low, it must be concluded that any rescue is highly unlikely. There appears to be ample seemingly suitable habitat all over the Manitoulin region and even within fairly short distances of the Great Duck Island subpopulations. The dunes at Wagosh Bay, Cockburn Island are only 72 km nearly due west of subpopulations on Bois Blanc Island, Michigan. Western Duck Island is only 9 km from Desert Point, sandy shores on Manitoulin Island are only 16 km away, and both southerly and westerly winds can be very strong during the fall. Although *S. gillmanii* is common and abundant in Michigan, it is mainly on the western side of the state on the Lake Michigan shoreline, which is much farther away. Rescue from that side of the state would be nearly impossible.

Given the lack of any detected successful long-distance dispersal in the last 18 years (Jones unpublished data), rescue seems very unlikely despite the abundance of available habitat. However, if propagules should reach Canadian habitats, it is very likely they would be able to grow.

THREATS AND LIMITING FACTORS

Threats

The International Union for Conservation of Nature (IUCN) Red List (IUCN 2019) unified threats classification system (Master *et al.* 2012) was used to evaluate levels of threats to *S. gillmanii* (Table 2). The overall threat impact was calculated as Low.

Most dune habitats in the Manitoulin region are subject to a number of anthropogenic threats (Parks Canada Agency 2011 and unpublished data 2004-2018) and usually have cottages all along the back part of the beach. However, Great Duck Island has no residents—seasonal or permanent, no road access, and is a fairly remote, even for most boaters. Major development of the island is unlikely. A very small amount of recreational use does occur from boaters landing on the beach, but in 2018, there was no evidence of camping, erosion from human foot traffic, ATV use, or garbage. There was no evidence of damage from deer browsing or significant insect herbivory in 2018, but this may vary from year to year. The main threat to *S. gillmanii* is from invasive species but other negligible or potential threats to *S. gillmanii* are assessed in detail in the threats calculator (Table 2).

Table 2. IUCN Threats Calculator for *Solidago gillmanii*.

Species or Ecosystem Scientific Name	*Solidago gillmanii*				
Element ID		**Elcode**			
Date (Ctrl + ";" for today's date):	May 14, 2019				
Assessor(s):	Judith Jones (report writer), Phyllis Higman (Michigan Natural Features Inventory), Vivian Brownell (VP SSC), Bruce Bennett (VP SSC), Karolyne Pickett (EC), Dan Brunton (VP SSC), Jana Vamosi (VP Co-Chair), Dave Fraser (faciliator), Karen Timm (COSEWIC Secretariat), Colin Jones (ON NHIC)				
References:	based on field observations and familiarity with other suitable habitats in the region.				
Overall Threat Impact Calculation Help:				**Level 1 Threat Impact Counts**	
		Threat Impact		**high range**	**low range**
	A	Very High		0	0
	B	High		0	0
	C	Medium		0	0
	D	Low		1	1
		Calculated Overall Threat Impact:		Low	Low
Assigned Overall Threat Impact:	**D=Low**				
Impact Adjustment Reasons:					
Overall Threat Comments	In Canada, *Solidago gillmanii* currently occurs only on dunes on the shores of Great Duck Island in northern Lake Huron south of Manitoulin Island. There are two subpopulations 2.5 km apart (Desert Point, with ~5000 mature individuals, or 77% of the population) and Horseshoe Bay, with ~1500 mature individuals, or 23% of the population). Generation time is unknown but likely several years to over a decade. For the purposes of this threats calculator we have used 5-15 years or a median of 10 years.				

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1	Residential & commercial development		Negligible	Negligible (<1%)	Serious (31-70%)	Low (Possibly in the long term, >10 yrs)	
1.1	Housing & urban areas		Negligible	Negligible (<1%)	Serious (31-70%)	Low (Possibly in the long term, >10 yrs)	Refers to the possibility of shoreline development at either dune site. Likelihood of this happening is considered low, but if it did occur it could result in a lot of use of the dunes which could lead to serious losses. This calculation is based on observations on Manitoulin Island of other dune sites with adjacent cottages and unrestricted beach use. Because this is unlikely to happen in 10 years, the scope is considered negligible but it is noted that this could become a bigger threat in the future. Housing development was likely a factor in the extirpation of the Deans Bay subpopulation but is unlikely at remaining subpopulations.
1.2	Commercial & industrial areas						
1.3	Tourism & recreation areas						
2	Agriculture & Aquaculture						
2.1	Annual & perennial non-timber crops						
2.2	Wood & pulp plantations						
2.3	Livestock farming & ranching						
2.4	Marine & freshwater aquaculture						
3	Energy production & mining						
3.1	Oil & gas drilling						
3.2	Mining & quarrying						
3.3	Renewable energy						
4	Transportation and service corridors						
4.1	Roads & railroads						
4.2	Utility & service lines						
4.3	Shipping lanes						
4.4	Flight paths						
5	Biological resource use						
5.1	Hunting & collecting terrestrial animals						
5.2	Gathering terrestrial plants						
5.3	Logging & wood harvesting						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
5.4	Fishing & harvesting aquatic resources						
6	Human intrusions & disturbance		Negligible	Small (1-10%)	Negligible (<1%)	High (Continuing)	
6.1	Recreational activities		Negligible	Small (1-10%)	Negligible (<1%)	High (Continuing)	Great Duck Island is remote, and recreational usage of the dunes where *Solidago gillmanii* resides is limited to occasional visits from boaters. Visits occur at both sites but only over small parts of the habitat, thus small scope. There was only a small amount of evidence it occurs, so slight severity. This calculation was based on field observations in 2018 and comments from the local OMNRF conservation officer, Iain McGale. A low level of disturbance may benefit the species but some activity (i.e., building of a fire pit) could affect ~1% of the population. In similar habitats in Michigan, people have been causing disturbance at remote sites. Fire pits have been seen in similar dune sites but not yet at these sites. Currently, with high water levels, there is very little beach, meaning recreational use will be on the dune vegetation, not on bare sand. Threats from recreational usage largely come from firepits, tenting, and foot traffic, but severity is considered negligible.
6.2	War, civil unrest & military exercises						
6.3	Work & other activities						
7	Natural system modification		Not Calculated (outside assessment timeframe)	Restricted (11-30%)	Moderate - Slight (1-30%)	Insignificant/Negligible (Past or no direct effect)	
7.1	Fire & fire suppression						
7.2	Dams & water management/use						
7.3	Other ecosystem modifications		Not Calculated (outside assessment timeframe)	Restricted - Small (1-30%)	Moderate - Slight (1-30%)	Insignificant/Negligible (Past or no direct effect)	At some dune sites in the Manitoulin region, landowners remove all dune vegetation in front of their property. This was not observed at Great Duck Island and is not expected to be a threat at that remote site. However, this activity occurs at Deans Bay and may have been a historical threat involved in the loss of that subpopulation.
8	Invasive & other problematic species & genes	D	Low	Restricted (11-30%)	Moderate (11-30%)	High (Continuing)	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
8.1	Invasive non-native/alien species	CD	Medium - Low	Restricted (11-30%)	Moderate - Slight (1-30%)	High (Continuing)	Refers to Glandular Baby's Breath present at Horseshoe Bay where there are 1500 individuals (23% of total population; thus restricted scope). Baby's Breath could potentially affect nearly all of the habitat or almost all individuals. The severity of this threat is scored as a range (moderate - slight) because it will probably have a cumulative effect (increasing over the next 10 years or 3 generations) as the density of the invasive increases. In Michigan, this invasive is having an effect on dune habitats, but other species are often able to grow alongside it. Baby's Breath probably affects establishment of new seedlings more than established plants. Invasive *Phragmites* was present at Horseshoe Bay in 2017, but control actions have taken place and *Phragmites* is no longer a threat. A recent report (Peach 2016) suggests that invasive species (such as invasive *Phragmites*) may become a more prevalent issue with the forecasted lake level extremes accompanying climate change.
8.2	Problematic native species						Browsing by White-tailed Deer (*Odocoileus virginianus*) probably occurs but was not observed to be a problem in 2018. Deer browsing of dune vegetation on Great Duck Island appears to fluctuate greatly from year to year. No evidence of browsing of this species was observed at these sites but there is evidence of deer eating other goldenrods at other sites. Not considered to be a big threat to this species.
8.3	Introduced genetic material						
9	Pollution						
9.1	Household sewage & urban waste water						
9.2	Industrial & military effluents						
9.3	Agricultural & forestry effluents						
9.4	Garbage & solid waste						
9.5	Air-borne pollutants						
9.6	Excess energy						
10	Geological events						
10.1	Volcanoes						
10.2	Earthquakes/tsunamis						
10.3	Avalanches/landslides						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
11	Climate change & severe weather		Unknown	Unknown	Unknown	High (Continuing)	
11.1	Habitat shifting & alteration		Unknown	Unknown	Unknown	High (Continuing)	There are a great number of unknowns with how climate change will affect this species. Dune dynamics must function to maintain some open sand. It is unknown whether increased frequency and severity of winter storms would lead to improved habitat (more open sand) or to destruction of some habitat. In the short term (10 years or 3 generations), the scope and severity of the impact of climate change are unknown but are not likely to be large. Most climate change projections expect lower lake levels, especially as ice cover has greatly decreased on Lake Huron (ECCC and USEPA 2017). Lower lake levels might temporarily increase the amount of dune habitat but could lead to longer periods without disturbance and an increase in natural succession.
11.2	Droughts						
11.3	Temperature extremes						
11.4	Storms & flooding						

8 Invasive & Other Problematic Species & Genes

8.1 Invasive Non-Native/Alien Species

The exotic species Glandular Baby's Breath is abundant at Horseshoe Bay. This species is able to compete for the same sparsely vegetated spots used by *S. gillmanii* and has very long roots which stabilize sand and allow other plant species to get established and fill in. As a result, there are fewer patches of open, loose sand in the dunes, and most of the sand is becoming fully vegetated. It is not known when this species was introduced to Great Duck Island, but it was already well established in 1976 (Morton and Venn 1984). This species is able to spread quickly and surveys of the Horseshoe Bay location since 2008 (see **Habitat Trends**) indicate a steady and substantial encroachment of this invasive species. Pringle (1976) reported that a population in Michigan went from two plants to over one hundred between 1963 and 1966.

Prior to 2018, several patches of the invasive European Common Reed were present in shallow water in front of the beach at Horseshoe Bay. Dense patches of this robust grass are able to alter wave-wash and ice dynamics and reduce natural disturbance on dunes (Jones pers. obs.). Control work was done in 2017 and 2018 by the Manitoulin Phragmites Project, and the invasive has now been nearly eliminated from the site (Manitoulin Phragmites Project 2018).

Limiting Factors

The limiting factors that naturally affect most dune species do not seem to be affecting *S. gillmanii.* For example, dune habitats are naturally uncommon and considered imperilled in Ontario (Natural Heritage Information Centre 2018). It is estimated that only 1800 ha of freshwater coastal dunes exist in Canada, with 492 ha on Lake Huron, 100 ha on Lake Superior and the remaining 1208 ha on Lakes Erie and Ontario (Bakowsky and Henson 2014). However, there is a large amount of suitable dune habitat available for *S. gillmanii* across the south shores of Manitoulin and Cockburn Islands and on Western Duck Island, so habitat is not limited for this species.

In addition, the natural dynamics of the dune ecosystem may limit some species. At times of heavier or more frequent natural disturbance (high lake levels, years with more frequent winter storms, etc.) areas of dune vegetation may be destroyed or drastically changed (Jones personal observations 2016-2017), which may affect the presence of *S. gillmanii*. There may also be periods of low natural disturbance (low lake levels, fewer winter storms, less wind, etc.), in which dune vegetation may fill in and become extremely dense, again creating unsuitable conditions. However, presumably species endemic to dunes are adapted to survive natural change cycles, even though population sizes and occurrence may be affected, because dynamic forces create and maintain habitat suitability. Since there is no evidence of recent declines, presumably, these factors are not having dramatic negative effects on *S. gillmanii*.

Number of Locations

Both Canadian subpopulations are on Great Duck Island, approximately 2.5 km apart, and are therefore threatened (albeit to differing degrees) by the main threat from the invasive species (Glandular Baby's Breath). This invasive species is currently impacting the Horseshoe Bay subpopulation but will likely disperse to Desert Point, given its proximity. According to the new IUCN guidelines (IUCN 2019), locations can be defined by the area of the population that is estimated to be severely reduced within a single generation or three years, whichever is longer. Given the rough estimate of generation time of 5-15 years, it is expected that a sizable amount (but not all) of the habitat can be impacted within that time frame (see **Habitat Trends**), and the definition of locations then requires subdivision of the Desert Point subpopulation. Although it is difficult to estimate the probability and timing of establishment of Baby's Breath at Desert Point, and some area near the lake will likely remain free of Baby's Breath, the number of locations is likely more than two but less than five.

PROTECTION, STATUS AND RANKS

Legal Protection and Status

Solidago gillmanii is not currently listed at-risk, so it is not protected by the federal *Species at Risk Act* (SARA) or the Ontario *Endangered Species Act 2007*. However, the habitat of species ranked S1 – S3 and provincially rare vegetation communities including dunes are considered Significant Wildlife Habitat in the natural heritage section of the Ontario Provincial Policy Statement (PPS; Ontario Ministry of Municipal Affairs and Housing 2014; Ontario Ministry of Natural Resources and Forestry 2015). Under the PPS, development and site alteration are restricted in Significant Wildlife Habitat. All of Great Duck Island is designated an area of natural and scientific interest (ANSI) (Ontario Ministry of Natural Resources 2018), which also carries restrictions to development under the PPS.

Unfortunately, there seems to be no enforcement of these protections as new construction activities appeared to be underway on the dunes at Deans Bay and on other dunes in the Manitoulin region during 2018 (Jones pers. obs.). However, Great Duck Island is a fairly remote locality with boat access only, so a major development there is rather unlikely.

Land use on Great Duck Island is administered by the Town of Northeastern Manitoulin and Islands (NEMI) in Little Current, Ontario. A new official plan governing land use for the Town of NEMI was waiting approval at the time of this writing, so it is unknown whether there are protections in place for dunes, ANSIs, and significant wildlife habitat. However, it is assumed that the new official plan must comply with Ontario's PPS.

Non-Legal Status and Ranks

In Wisconsin and Indiana *S. simplex* var. *gillmanii* is state-listed as Threatened and ranked S2 or imperiled (Indiana DNR 2016; Wisconsin DNR 2015). In Michigan, *S. gillmanii* is not ranked (SNR) of conservation concern (Michigan Natural Features Inventory 2018). In the United States as a whole, the species is nationally ranked N3? (Vulnerable with some uncertainty). In Ontario, the species is currently ranked S1 or critically imperilled (Natural Heritage Information Centre 2018). In Canada, the species is nationally ranked N1 or critically imperilled (NatureServe 2018). The rounded global status of the taxon as a variety is T3 or globally vulnerable. The global status has not been reviewed since 2003 (NatureServe 2018).

Habitat Protection and Ownership

On the shorelines of Manitoulin region, the area below the surveyed historical high-water mark is in municipal jurisdiction. Thus, part of the habitat at most beaches is municipally controlled. On some beaches, the high-water mark was surveyed in the original land surveys of the 1880s. On others, the high-water mark is considered the start of the permanent vegetation (the trees). It is unlikely that Great Duck Island was ever surveyed, and no survey bars are evident at either dune site (Jones pers. obs.). The dune areas at

both sites on Great Duck Island are large enough and extend far enough from the water that most of the habitat is on private land. All of Great Duck Island is privately owned as a single parcel.

All islands surrounding Manitoulin Island, including Great Duck Island, are under land claim by Wiikwemkoong Unceded Territory. Wiikwemkoong has maintained a program to protect species at risk since 2007, and lands with species at risk are designated as no development within the community's land use plan (J. Manitowabi pers. comm. 2018).

ACKNOWLEDGEMENTS AND AUTHORITIES CONTACTED

Dr. J.C. Semple, Professor Emeritus, University of Waterloo, Ontario is heartily thanked for providing expert assistance to Judith Jones and for confirming the identities of several collections. In addition, very helpful data were received from Tony Reznicek (University of Michigan MICH herbarium), Luc Brouillet (Université de Montréal, Marie-Victorin MT herbarium), and Deborah Metzger (Royal Ontario Museum, University of Toronto TRT herbarium). Judith Jones's ongoing use of J.K. Morton and Joan Venn's Manitoulin database is also very gratefully acknowledged.

INFORMATION SOURCES

Albert, D. 2000. Borne of the Wind: An introduction to the ecology of Michigan's sand dunes. Michigan Natural Features Inventory, Lansing, Mi. 63 pp.

Bakowsky, W.D. and B.L. Henson. 2014. Rare Communities of Ontario: Freshwater Coastal Dunes. Natural Heritage Information Centre. Ontario Ministry of Natural Resources. 10 pp. + appendices.

Brouillet, L., F. Coursol, S.J. Meades, M. Favreau, M. Anions, P. Bélisle, and P. Desmet. 2010+. VASCAN, the Database of Vascular Plants of Canada. Website: http://data.canadensys.net/vascan/ [accessed October 19, 2018].

Brouillet, L. pers. comm. 2018. *Email correspondence to Judith Jones* April 13, April 24, and October 16, 2018. Department of Biological Sciences, Université de Montréal and Herbarium Marie-Victorin (MT), Montreal, Quebec.

Buchele, D., J. Baskin and C. Baskin. 1992. Ecology of the Endangered Species *Solidago shortii.* IV. Pollination Ecology. Bulletin of the Torrey Botanical Club 119(2):137-141.

Carthey, A.J.R., K.A. Fryirs, T.J. Ralph, H. Bu and M.R. Leishman. 2016. How seed traits predict floating times: a biophysical process model for hydrochorous seed transport behaviour in fluvial systems. Freshwater Biology 61:19-31

Consortium of Midwest Herbaria 2018. *Solidago gillmanii* in online searchable database; http://midwestherbaria.org/portal/collections/list.php [accessed November 29, 2018].

COSEWIC 2010a. COSEWIC assessment and status report on the Pitcher's Thistle *Cirsium pitcheri* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. x + 32 pp.

COSEWIC. 2010b. COSEWIC assessment and status report on the Showy Goldenrod *Solidago speciosa* (Great Lakes Plains and Boreal Populations) in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xiv + 23 pp.

COSEWIC. 2015. COSEWIC assessment and status report on the Lake Huron Grasshopper *Trimerotropis huroniana* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. ix + 32 pp.

Cronquist, A. 1947. Notes on the Compositae of the Northeastern United States V. Astereae. Bulletin of the Torrey Botanical Club 74(2):142-150.

Czarnecka, J., G. Orłowski and J. Karg. 2012. Endozoochorous dispersal of alien and native plants by two palearctic avian frugivores with special emphasis on invasive giant goldenrod *Solidago gigantea*. Open Life Sciences *7*(5):895-901.

Dech, J.P., M.A. Maun and M.I. Pazner. 2005. Blowout dynamics of Lake Huron sand dunes: analysis of digital multispectral data from colour air photos. Catena 60:165-180.

Environment Canada. 2015. Management Plan for the Riddell's Goldenrod (*Solidago riddellii*) in Canada. *Species at Risk Act* Management Plan Series. Environment Canada, Ottawa. iv + 18 pp.

Environment and Climate Change Canada 2019. Historical weather for Gore Bay, ON. http://climate.weather.gc.ca/climate_data/daily_data_e.html?StationID=48788 [accessed March 27, 2019].

Environment and Climate Change Canada and the U.S. Environmental Protection Agency. 2017. State of the Great Lakes 2017 Technical Report. Cat No. En161-3/1E-PDF. EPA 905-R-17-001. https://binational.net/wp-content/uploads/2017/09/SOGL_2017_Technical_Report-EN.pdf [accessed March 27, 2019].

Erichsen-Brown, C. 1979. Use of Plants for the Past 500 Years. Breezy Creeks Press, Aurora, Ontario. 510 pp.

Farwell, O. 1930. Botanical Gleanings in Michigan. The American Midland Naturalist 12(2):44-78.

Fernald, M.L. 1908. Notes on some plants of Northeastern America (continued), Rhodora 10(113):84-95.

Frances, A. personal communication 2019. Email correspondence to B. Bennett on February 18, 2019. NatureServe, Arlington, VA.

Gleason, H.A. 1952. The New Britton and Brown Illustrated Flora of the Northeastern United States and Adjacent Canada, v. 3. New York Botanical Garden and Hafner Publishing Co., New York. 596 pp.

Gleason, H.A. and A. Cronquist. 1991. Manual of Vascular Plants of Northeastern United States and Adjacent Canada, 2nd ed. New York Botanical Garden, Bronx, NY 910 pp.

GoogleEarth Pro 2013. Software package, version 7.1.2.2041. https://www.google.com/earth/.

Government of Canada. 2016. Houghton's goldenrod (*Solidago houghtonii*) COSEWIC assessment and status report: chapter 11 Technical Summary. Species at Risk Public Registry,Website: https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry/cosewic-assessments-status-reports/houghtons-goldenrod/chapter-11.html [accessed April 8, 2019].

Gray, A. 1882. XII. Contributions to North American Botany: I. Studies of Aster and Solidago in Older Herbaria. Proceedings of the American Academy of Arts and Sciences 17:163-230.

Gross, R.S. and P.A. Werner. 1983. Relationships among flowering phenology, insect visitors, and seed-set of individuals: experimental studies on four co-occurring species of goldenrod (*Solidago*: Compositae). Ecological Monographs 53(1):95-117.

Herbarium Marie-Victorin (MT) 2018. Unpublished catalog data. University of Montreal, Montreal, Quebec.

Higgins, S.I., R. Nathan, and M.L. Cain. 2003. Are long-distance dispersal events in plants usually caused by nonstandard means of dispersal? Ecology, 84(8):1945-1956.

IUCN Red List 2019. Classification Schemes: Threats. Website: https://www.iucnredlist.org/resources/classification-schemes [accessed May 22, 2019].

IUCN Standards and Petitions Committee. 2019. Guidelines for Using the IUCN Red List Categories and Criteria. Version 14. Prepared by the Standards and Petitions Committee. Downloadable from http://www.iucnredlist.org/documents/RedListGuidelines.pdf [accessed November 24, 2019].

Indiana Department of Natural Resources. 2016. List of Endangered, Threatened & Rare Vascular Plants of Indiana. https://www.in.gov/dnr/naturepreserve/4725.htm [accessed November 30, 2018].

Jolls, C.L. and P.M. Tolley. Undated. The reproductive ecology of a Great Lakes endemic Houghton's Goldenrod (*Solidago houghtonii* A. Gray, Torr. & Gray ex Gray). Unpublished manuscript. East Carolina University, Greenville, NC. 36 pp.

Jones, J. 2001. Survey of Pitcher's Thistle and dune grasslands in the Manitoulin District. Unpublished report to Parks Canada Agency, Ottawa. 2 pp.

Jones, J. 2002. Survey of dune grasslands on southern Lake Huron; report from the survey of 24 dune sites. Unpublished report to Parks Canada Agency, Ottawa. 5 pp.

Jones, J. 2003. Report from the survey of 11 dune sites. Unpublished report to Parks Canada Agency, Ottawa. 3 pp.

Jones, J. 2004. Status of Pitcher's Thistle (*Cirsium pitcheri*) and dune grasslands in the Manitoulin Region. Unpublished report to Parks Canada Agency, Ottawa. 6 pp.

Jones, J. 2005. Report from monitoring Pitcher's Thistle, 2005. Unpublished report to Parks Canada Agency, Ottawa. 5 pp.

Jones, J. 2006. Dune grasslands on the North Shore of Lake Huron and North Channel Islands. Unpublished report to Parks Canada Agency, Ottawa. 4 pp.

Kartesz, J.T. 2015 The Biota of North America Program (BONAP). *North American Plant Atlas.* http://bonap.net/Napa/TaxonMaps/Genus/State/Solidago [accessed November 29, 2018].

Lawrence, G.H.M. 1951. Taxonomy of Vascular Plants. Macmillan, New York. 823 pp.

Lee, H.T., W.D. Bakowsky, J. Riley, J. Bowles, M. Puddister, P. Uhlig, and S. McMurray. 1998. Ecological land classification for southern Ontario: first approximation and its application. SCSS Field Guide FG-02. Ontario Ministry of Natural Resources, Southcentral Science Section, North Bay, Ontario.

Locke, M. pers. comm. 2018. *Email communication with J. Jones* November 27, 2018. Systematics Assistant in Entomology, Canadian National Collection of Insects, Arachnids, and Nematodes, Agriculture and Agri-Food Canada, Ottawa.

Manitoulin Phragmites Project, 2017. Results of 2017 work. Unpublished letter. 6 pp. Available from manitoulinphrag@yahoo.com.

Manitoulin Phragmites Project 2018. Results of 2018 work. Unpublished letter. 8 pp. Available on Facebook: @manitoulinphrag [accessed November 30, 2018].

Manitowabi, J. pers. comm. 2018. *In person communication to J. Jones*, July 2015 and December 4, 2018. Director, Department of Lands and Natural Resources, Wiikwemkoong Unceded Territory, Ontario.

Master L., D. Faber-Langendoen, R. Bittman, G. A. Hammerson, B. Heidel, L. Ramsay,

K. Snow, A. Teucher, and A. Tomaino. 2012. NatureServe Conservation Status Assessments: Factors for Evaluating Species and Ecosystem Risk. NatureServe, Arlington, VA. 64 pp.

Maun, M.A. 2009. The Biology of Coastal Sand Dunes. Oxford University Press. 265 pp.

Meyer, A.H. and B. Schmid. 1999. Seed dynamics and seedling establishment in the invading perennial *Solidago altissima* under different experimental treatments. Journal of Ecology 87(1):28-41.

Michigan Natural Features Inventory, 2018. Michigan's Rare Plants. https://mnfi.anr.msu.edu/species/plants [accessed November 30, 2018].

Moerman, D.E. 1998. Native American Ethnobotany. Timber Press, Portland Oregon. 927 pp.

Morton, J.K. and J.M. Venn. 1984. The Flora of Manitoulin Island, 2nd ed. University of Waterloo Biology Series Number 28. Waterloo, Ontario.

Morton, J.K. and J.M. Venn. 2000. The Flora of Manitoulin Island, 3rd ed. University of Waterloo Biology Series Number 40. Waterloo, Ontario.

Morton, J.K. and J.M. Venn 2010. Unpublished database of compiled collections records for Manitoulin Island. On file at the herbarium of the University of Toronto (TRT) and used with permission.

Nagy, P.L., K. Tory, A. Kolonics, A. Keri, L. Laszlo, L. Jaszlits, A. Bajza, S. Bernath, L. Vigh, T. Bodnar, and J. Egri. 2009a. Pharmaceutical composition containing an extract of a *Solidago* species. U.S. Patent Application 11/991,362. https://patents.google.com/patent/US20090214677A1/en [accessed April 9, 2018].

Nagy P.L, Z. Lohinai, K. Tory, A. Kolonics, A. Keri, O. Rigo, A. Huszak, B. Zahonyi, S. Bernath, L. Vigh, and T. Bodnar. 2009b. Composition for the treatment of diabetic periodontitis. United States patent application US 12/089,762. https://patents.google.com/patent/US20090130234A1/en [accessed April 9, 2018].

Nathan, R., F.M. Schurr, O. Spiegel, O. Steinitz, A. Trakhtenbrot, and A. Tsoar. 2008. Mechanisms of long-distance seed dispersal. Trends in Ecology and Evolution, 23(11):638-647.

Natural Heritage Information Centre. 2018. On-line databases: Ontario plant community list 2 and List of Tracked Species. Ontario Ministry of Natural Resources and Forestry, https://www.ontario.ca/page/get-natural-heritage-information [accessed March 27, 2019].

NatureServe. 2018. NatureServe Explorer: online database. NatureServe, Arlington, Virginia. http://explorer.natureserve.org [accessed: November 30, 2018].

Ontario Ministry of Municipal Affairs and Housing. 2014. Provincial Policy Statement Under the Planning Act 2014. http://www.mah.gov.on.ca/Page10679.aspx [accessed November 30, 2018].

Ontario Ministry of Natural Resources and Forestry. 2015. Significant Wildlife Habitat Criteria Schedules for Ecoregion 6E. https://www.ontario.ca/document/significant-wildlife-habitat-ecoregional-criteria-schedules-ecoregion-6e [accessed November 30, 2018].

Ontario Ministry of Natural Resources and Forestry. 2018. Make a Map online interactive GIS application. http://www.gisapplication.lrc.gov.on.ca/mamnh/Index.html?site=MNR_NHLUPS_NaturalHeritage&viewer=NaturalHeritage&locale=en-US [accessed November 19, 2018].

Parks Canada Agency. 2004-2018. Unpublished annual population census data for Pitcher's Thistle. Office of the Chief Ecosystem Scientist, Gatineau, Quebec.

Parks Canada Agency. 2011. Recovery Strategy for Pitcher’s Thistle (*Cirsium pitcheri*) in Canada. Species at Risk Act Recovery Strategy Series. Parks Canada Agency. Ottawa. x + 31 pp.

Peach, G.H. 2016. Beaches, dunes and climate change. Coastal Bulletin 16-1, Lake Huron Centre for Coastal Conservation, Blyth, Ontario. 9 pp.

Peirson, J.A., A.A. Reznicek, and J.C. Semple. 2012. Polyploidy, infraspecific cytotype variation, and speciation in Goldenrods: The cytogeography of *Solidago* subsect. *Humiles* (Asteraceae) in North America. Taxon 61(1):197–210.

Peirson, J.A., C.W. Dick, and A.A. Reznicek. 2013. Phylogeography and polyploid evolution of North American goldenrods (*Solidago* subsect. *Humiles*, Asteraceae) Journal of Biogeography 40:1887-1898.

Porter, T.C. 1893. *Solidago humilis* Pursh, of the eastern states, and its allies. Bulletin of the Torrey Botanical Club 20(5):207-211.

Pringle, J.S. 1976. *Gypsophila scorzonerifolia* (Caryophyllaceae), a naturalized species of the Great Lakes region. Michigan Botanist 15:215-219.

Quinn, F.H. and C.E. Sellinger. 2006. A reconstruction of Lake-Michigan-Huron water levels derived from tree ring chronologies for the period 1600-1961. J. Great Lakes Research 32:29-39.

Reznicek, A.A., E.G. Voss, and B.S. Walters. 2011. Michigan Flora Online. University of Michigan. https://michiganflora.net/ [accessed November 23, 2018].

Reznicek, A.A. pers. comm. 2018-2019. *Email correspondence to J. Jones* April 9, 2018 and to B. Bennett on February 18, 2019. Research Scientist and Curator of Vascular Plants, University of Michigan Herbarium, Ann Arbor, Michigan.

Ringius, G.S. 1987. Lectotypifications and a New Combination in the *Solidago spathulata* DC.-*S. glutinosa* Nutt. Complex (Compositae: Astereae). Taxon, 36(1):154-157.

Ringius, G.S. and J.C. Semple. 1991. New combinations in *Solidago simplex* (Compositae: Astereae). Phytologia 70:396-399.

Semple, J.C. 2016. An intuitive phylogeny and summary of chromosome number variation in the goldenrod genus *Solidago* (Asteraceae: Astereae). Phytoneuron 2016-32:1-9.

Semple, J.C. 2018. Classification and illustrations of goldenrods. Web page of the University of Waterloo Astereae Laboratory. https://uwaterloo.ca/astereae-lab/research/goldenrods/classification-and-illustrations [accessed November 23, 2018].

Semple, J.C. pers. comm. 2018. *Email correspondence to J. Jones* March 27, March 28, and October 16, 2018. Professor Emeritus, Department of Biology, University of Waterloo, Waterloo, Ontario.

Semple, J.C., G.S. Ringius and J.J. Zhang. 1999. Goldenrods of Ontario, 3rd ed. University of Waterloo Biology Series, No. 39.

Semple, J.C. and R.E. Cook. 2006. *Solidago* L. pp. 107–166, *in* Flora North America Editorial Committee (eds.). Flora of North America, v. 20. Oxford University Press, New York.

Semple, J.C. and J. Peirson. 2013. A revised nomenclature for the *Solidago simplex* complex (Asteraceae: Astereae). Phytoneuron 2013(41):1-5 .

Semple, J.C., Y. Ma and L. Tong. 2016. On *Solidago simplex* (Asteraceae: Astereae): a multivariate study including *S. glutinosa*, *S. leiocarpa*, *S. multiradiata* and *S. spathulata*. Phytoneuron 2016-87:1-21.

Sheldon, J.C. and F.M. Burrows 1973. The dispersal effectiveness of the achene-pappus units of selected compositae in steady winds with convection. New Phytologist 72:665-675.

Soons, M.B., G.W. Heil, R. Nathan, and G.G. Katul. 2004. Determinants of long-distance seed dispersal by wind in grasslands. Ecology 85(11):3056-3068.

Spyreas, G., I.S. Pearse, D.L. Nickrent, N.M.Greenwood, A. Epstein, and P. Anders. (eds.) 2017. Illinois Plants: a web-based database for the flora of Illinois. https://www.inhs.illinois.edu/data/plantdb [accessed March 27, 2019].

Steele, E.S. 1911. New or noteworthy plants from the eastern United States. Contributions from the United States National Herbarium, 13(10):359-374.

Tackenberg, O., P. Poschlod, and S. Bonn. 2003. Assessment of wind dispersal potential in plant species. Ecological Monographs 73(2):191-205.

Thomson, F.J., A.T. Moles, T.D. Auld and R.T. Kingsford. 2011. Seed dispersal distance is more strongly correlated with plant height than with seed mass. Journal of Ecology 99(6):1299-1307.

University of Michigan Herbarium (MICH) 2018. Unpublished catalog data. Ann Arbor, Michigan.

USDA 2019. State plant checklist for Illinois. USDA Natural Resources Conservation Service, https://plants.sc.egov.usda.gov/dl_state.html [accessed March 27, 2019].

Vogel, V.J. 1970. American Indian Medicine. University of Oklahoma Press, Norman, OK. 578 pp.

Voss, E.G. 1978. Botanical beachcombers and explorers: pioneers of the 19th century in the Upper Great Lakes. Contributions from the University of Michigan Herbarium v. 13. Ann Arbor, Michigan. 100 pp.

Voss, E.G. 1996. Michigan Flora, v. 3. Cranbrook Institute of Science, Ann Arbor, Michigan. 622 pp.

Werner, P.A., R.S. Gross, and I.K. Bradbury. 1980. The biology of Canadian weeds: 45. *Solidago canadensis* L. Canadian Journal of Plant Science, 60(4):1393-1409.

Wiikwemkoong Department of Lands and Natural Resources, undated-a. Interesting Plants and Shrubs of Wikwemikong—Species at risk and more. Wiikwemkoong, Ontario. 48 pp.

Wiikwemkoong Department of Lands and Natural Resources, undated-b. Useful Plants of Wiikwemkoong Territory—Edible, medicinal, and other uses. Wiikwemkoong, Ontario. 28 pp.

Wiikwemkoong Department of Lands and Natural Resources, undated-c. Interesting & Useful Plants of Wiikwemkoong —Species at risk and more. Wiikwemkoong, Ontario. 52 pp.

Wilcox, D.A, T.A. Thompson, R.K. Booth, and J.R. Nicholas. 2007. Lake-level variability and water availability in the Great Lakes. U.S. Geological Survey Circular 1311, 25 pp.

Wisconsin Department of Natural Resources. 2015. Wisconsin Endangered and Threatened Species Laws & List. Publ-ER-001-2004. https://dnr.wi.gov/files/PDF/pubs/er/ER001.pdf [accessed November 30, 2018].

BIOGRAPHICAL SUMMARY OF REPORT WRITER

This report was prepared by Judith Jones, Winter Spider Eco-Consulting. Jones has been studying and monitoring Pitcher's Thistle and its dune habitat since 2000. As part of that work she has surveyed all major dune systems on the Canadian side of Lake Huron as well as 65 sand beaches on the North Shore and islands in the North Channel. Annual monitoring takes her regularly to all of the dunes and beaches in the Manitoulin region. She also works extensively on other species at risk and has written six other COSEWIC status reports as well as more than 30 recovery strategies and management plans. Her other work includes environmental impact studies (EIS) for development applications, field surveys for land management, and on-the-ground control of invasive species. She has lived on Manitoulin Island since 1988.

COLLECTIONS EXAMINED

A photo of the collection (as *S. racemosa* Greene) by J.K. Morton and Joan Venn on August 5, 1976 from Desert Point was examined. The identification was confirmed by J.C. Semple in 2013. As well, photos of collections by Semple from northern Michigan and northern Indiana were examined for comparison of morphological characteristics. Two collections of *Solidago* from dunes by Jones in 2006 were rechecked, but Semple had determined these to be *S. hispida*. A photo of the collection from Deans Bay by G. Ringius and J. Wilson on August 20, 1976 was also examined. The identification was confirmed as *S. gillmanii* by Semple in 2014. The plant looks very similar to individuals on Great Duck Island. A photo of this specimen was available at the time of writing at http://media.canadensys.net/mt-specimens/large/MT00228067.jpg or through the website of the Marie-Victorin (MT) Herbarium. Photos of some other specimens and other species of *Solidago* can be seen at Semple (2018).

Appendix 1. List of English and Latin names of goldenrods (genus *Solidago*) discussed in the text (sources: Morton and Venn 1984; Semple and Cook 2006; Brouillet *et al.* 2010; Semple 2018).

Latin Name	English Name
Solidago altissima	Tall Goldenrod
Solidago canadensis	Canada Goldenrod
Solidago gigantea	Giant Goldenrod or Late Goldenrod
Solidago gillmanii	Gillman's Goldenrod
Solidago glutinosa	Western Sticky Goldenrod
Solidago hispida var. *hispida*	Hairy Goldenrod
Solidago hispida var. *huronensis*	Lake Huron Goldenrod
Solidago houghtonii	Houghton's Goldenrod
Solidago humilis	Northern Bog Goldenrod
Solidago juncea	Early Goldenrod
Solidago nemoralis	Grey-stemmed Goldenrod
Solidago ontarioensis	Ontario Goldenrod
Solidago racemosa	Racemose Goldenrod
Solidago simplex	Mexican Sticky Goldenrod
Solidago simplex ssp. *randii*	Rand's Goldenrod
Solidago spathulata	Mountain or Coast Goldenrod
Solidago speciosa	Showy Goldenrod
Solidago stricta	Sticky Goldenrod
Solidago uliginosa	Bog Goldenrod

Appendix 2. List of associate species found in dune habitats with *S. gillmanii*. (Sources: Morton and Venn 2000; Brouillet *et al.* 2010).

Latin Name	Common English Name
Achillea millefolium	Yarrow
Ammophila breviligulata	Marram Grass
Anemone multifida	Cut-leaved Anemone
Anticlea elegans	Camass Lily
Arabidopsis lyrata	Lyre-Leaved Rock Cress
Boechera holboellii	Holboell's Rock Cress
Arctostaphylos uva-ursi	Common Bearberry
Artemisia campestris	Field Wormwood
Betula papyrifera	Paper Birch
Calamagrostis stricta ssp. *inexpansa*	Northern Reed Grass
Campanula gieseckeana	Giesecke's Bellflower
Cirsium pitcheri	Pitcher's Thistle
Cladina spp.	Reindeer Lichens
Corispermum americanum	American Bugseed
Cornus sericea	Red Osier Dogwood
Dasiphora fruticosa	Shrubby Cinquefoil
Elymus lanceolatus ssp. *psammophilus*	Great Lakes Wheatgrass
Equisetum hyemale	Common Scouring Rush
Euthamia graminifolia	Grass-leaved Goldenrod
Festuca saximontana	Rocky Mountain Fescue
Gentianopsis virgata	Lesser Fringed Gentian
Gypsophila scorzonerifolia	Glandular Baby's Breath
Hypericum kalmianum	Kalm's St. John's Wort
Juncus balticus	Baltic Rush
Juniperus communis	Common Juniper
Juniperus horizontalis	Creeping Juniper
Larix laricina	Tamarack
Lathyrus japonicus	Beach Pea
Lithospermum caroliniense	Golden Puccoon
Maianthemum stellatum	Starry False Solomon's Seal
Oenothera biennis	Evening Primrose
Dichanthelium acuminatum	Tapered Panic Grass
Picea glauca	White Spruce
Pinus resinosa	Red Pine
Pinus strobus	White Pine
Poa compressa	Canada Bluegrass
Populus balsamifera	Balsam Poplar
Potentilla anserina	Silverweed
Prunus pumila var. *depressa*	Sand Cherry
Rosa acicularis	Prickly Rose
Salix candida	Sage-leaved Willow
Salix cordata	Heart-leaved Willow
Salix discolor	Pussy Willow

Latin Name	**Common English Name**
Salix myricoides	Blue-leaved Willow
Schizachyrium scoparium	Little Bluestem
Shepherdia canadensis	Soapberry
Solidago hispida var. *hispida*	Hairy Goldenrod
Solidago hispida var. *huronensis*	Lake Huron Goldenrod
Solidago nemoralis	Grey-stemmed Goldenrod
Solidago ohioensis	Ohio Goldenrod
Sporobolus rigidus var. *magnus*	Long-leaved Reed Grass
Symphyotrichum ericoides	Heath Aster
Thuja occidentalis	Eastern White Cedar