

COSEWIC
Assessment and Status Report

on the

Skinner's Agalinis
Agalinis skinneriana

in Canada



ENDANGERED
2010

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. 2010. COSEWIC assessment and status report on the Skinner's Agalinis *Agalinis skinneriana* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xi + 24 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

Previous report(s):

COSEWIC. 2000. COSEWIC assessment and update status report on the Skinner's Agalinis *Agalinis skinneriana* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 10 pp.

Canne-Hilliker, J.M. 2000. Update COSEWIC status report on the Skinner's Agalinis *Agalinis skinneriana* in Canada, in COSEWIC assessment and update status report on the Skinner's Agalinis *Agalinis skinneriana* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 1-10 pp.

Canne-Hilliker, J.M. 1988. COSEWIC status report on the Skinner's Agalinis *Agalinis skinneriana* in Canada. Committee on the Status of Endangered Wildlife in Canada. 26 pp.

Production note:

COSEWIC would like to acknowledge Jane M. Bowles, Rachel C. White, and Clinton R. Jacobs for writing the status report on the Skinner's Agalinis *Agalinis skinneriana* in Canada, prepared under contract with Environment Canada, overseen and edited by Erich Haber, Co-chair, COSEWIC Vascular Plants Species Specialist Subcommittee.

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Également disponible en français sous le titre Évaluation et Rapport de situation du COSEPAC sur la gérardie de Skinner (*Agalinis skinneriana*) au Canada.

Cover illustration/photo:
Skinner's Agalinis — Photo: Jane M. Bowles.

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Catalogue No. CW69-14/202-2011E-PDF

ISBN 978-1-100-18578-1



Recycled paper



COSEWIC Assessment Summary

Assessment Summary – November 2010

Common name

Skinner's Agalinis

Scientific name

Agalinis skinneriana

Status

Endangered

Reason for designation

A highly restricted annual species of tallgrass prairie known in Canada from only two populations in southwestern Ontario. Recent losses of subpopulations have resulted in a decline in range, habitat area and quality, and number of mature individuals.

Occurrence

Ontario

Status history

Designated Endangered in April 1988. Status re-examined and confirmed Endangered in April 1999, May 2000, and November 2010.



COSEWIC
Executive Summary

Skinner's Agalinis
Agalinis skinneriana

Wildlife species description and significance

Skinner's Agalinis (*Agalinis skinneriana*) is a small, slender, annual, herb that may reach 65 cm in height. The stem is usually simple or with a few ascending branches in the upper plant, square in cross-section with stiff corners and slightly rough on the angles. The leaves are more or less opposite, without stalks, linear, and up to 2 mm wide and 20 mm long. Both the leaves and stem are a yellowish green, diffused with brownish purple late in the season, but drying green. The inflorescence is a raceme, with usually one, but sometimes two flowers per node. The flower stalk is 5-20 mm long, sometimes becoming longer in fruit. The fused petals are white, sometimes with a pale flush of the faintest pink. Capsules are roundish, about 4-5 mm in diameter and split open at maturity. The seeds are brownish yellow, triangular and covered with a net-like ridging on the seed coat.

There are no known economic or ethnobotanical uses for Skinner's Agalinis. The species, like others in the genus, is of special biological interest because of its hemiparasitic nature.

Distribution

Skinner's Agalinis is restricted to central and eastern North America and is most frequent in the Midwest and south-central United States. It has been recorded in Arkansas (historic only), Illinois, Indiana, Iowa, eastern Kansas, Louisiana, Maryland, southeast Michigan, Mississippi, Missouri, Ohio, and Wisconsin, as well as southwestern Ontario. In Canada, it is known from Walpole Island First Nation (WIFN) and from the City of La Salle adjacent to Windsor.

Habitat

Throughout its range Skinner's *Agalinis* grows in dry to moist prairies, in open woods on shallow soil over limestone, chert and granite, in open rocky glades, bluffs, barrens and in pockets among dunes. All the Canadian populations grow in mesic to moist prairies. The WIFN sites are all in tallgrass prairie sites on sandy loam.

Biology

Skinner's *Agalinis* flowers in late summer to early fall. The flowers are ephemeral, usually falling by midday on the day they open, although some will last until mid-afternoon. The species is bee-pollinated but is able to self-pollinate at a potentially high rate. No herbivory has been noted except that some capsules are emptied by the larva of an unknown insect. The seeds have no obvious mechanisms for long-distance dispersal. Short-distance dispersal likely occurs when seeds are shaken out of the capsules by wind, and seeds may float and be carried short distances in surface runoff during summer thunderstorms.

The species is partially parasitic, producing specialized root structures (haustoria) that attach to the roots of host species. It probably has a range of host species, but the only confirmed connection is to Little Bluestem.

Population sizes and trends

In total there are 6 documented populations of Skinner's *Agalinis* in Canada with five of these at WIFN, based on a distance of more than 1 km between populations. Of these five, one population is likely extirpated because of land use change. Plants at two other populations have not been seen since 1985 and 1997 and may be extirpated, although suitable habitat exists and the plants may have been overlooked. Two populations at WIFN contain most of the individuals. In 2008, the number of flowering plants was estimated to be about 6,000 in three stands in one population and about 17,000 in two stands in a second population. No plants were found at La Salle in 2008, but some plants were seen there in some years prior to this date.

Population trends are difficult to estimate because accurate counts were not made for any population before 2003. At sites where plants have been counted at least twice since 2003, no consistent trend in population size is evident. Because the plant is an annual, fluctuations in population size are expected. At La Salle, the most likely explanation for the apparent reduction (or possible disappearance) of the population is encroachment by woody species.

Threats and limiting factors

The major limiting factor for Skinner's Agalinis in Canada is probably the decline of the specialized tallgrass prairie habitat where it occurs. Conversion to agriculture, housing and other land uses have reduced the habitat at WIFN. The rate of conversion of prairie to agriculture has been reduced on WIFN because of an active campaign by the Walpole Island Heritage Centre to lease the land for conservation, but the threat remains, especially on private land. Direct trampling, especially from ATV traffic may also be a factor. Invasive species, particularly White Sweet Clover, are invading several sites and causing a decline in habitat quality. Lack of fire is allowing populations of fire-intolerant woody species to increase. This is a threat at La Salle and may have reduced habitat at WIFN where the frequency of fire is declining as more houses are built. A late spring fire in 2008 may have contributed to a reduction in the number of plants at one site on WIFN in 2008. Skinner's Agalinis may also be affected by changes in moisture regime as a result of dredging and ditching operations and natural changes in lake levels. High water levels during the late 1980s may have extirpated one population.

Protection, status, and ranks

Skinner's Agalinis is listed as Endangered under Schedule 1 of the federal *Species at Risk Act*, which confers protection to species on Federal Land, including Walpole Island First Nation. In Ontario, it is listed as Endangered under the *Endangered Species Act, 2007* and receives species and general habitat protection. The species has a Global rank of vulnerable to apparently secure and a U.S. national rank of vulnerable. It has a rank of critically imperilled in Canada and in Ontario.

TECHNICAL SUMMARY

Agalinis skinneriana

Skinner's Agalinis

Range of occurrence in Canada: Ontario

G rardie de Skinner

Demographic Information

Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines(2008) is being used)	1 year
Is there an observed, inferred, or projected continuing decline in number of mature individuals? Some sites have been lost, but there are no data that show decline of mature individuals at the sites where most individuals occur. Uncertainty also exists as a result of population fluctuation.	Unknown
Estimated percent of continuing decline in total number of mature individuals within 5 years.	Unknown
Observed, estimated, inferred, or suspected percent [reduction or increase] in total number of mature individuals over the last 10 years.	Unknown
Projected or suspected percent reduction or increase in total number of mature individuals over the next 10 years.	Unknown
Observed, estimated, inferred, or suspected percent [reduction or increase in total number of mature individuals over any 10 years period, over a time period including both the past and the future.	Unknown
Are the causes of the decline clearly reversible and understood and ceased?	No
Are there extreme fluctuations in number of mature individuals? This is an annual species. The role and longevity of seeds in the seed bank is unknown. Single season events (such as summer drought or fire) after seeds have germinated would cause extreme fluctuations. Fluctuations have been detected year to year in the number of flowering plants.	Unknown if extreme fluctuations occur

Extent and Occupancy Information

Estimated extent of occurrence	70 km ²
Index of area of occupancy (IAO) The actual area of occupancy is about 4.3 ha.	20 km ² (2x2 km grid)
Is the total population severely fragmented? Likely not based on the presence of two large viable populations with potentially some undiscovered sites at WIFN.	No
Number of "locations" (as per definition, in relation to threat) Based on the various threats at the remaining subpopulations at WIFN and at the La Salle site, there are possibly fewer than five locations in total and perhaps only two.	Possibly as few as 2
Is there an observed, inferred, or projected continuing decline in extent of occurrence? No plants were seen at the La Salle population in 2008; because of its previous small size and ongoing threats this population may not be viable or even extant. Depending on the status of this population, a decline in the EO is projected.	Yes
Is there an observed, inferred, or projected continuing decline in index of area of occupancy? Some sites have been lost due to development, plants at others are threatened.	Yes

Is there an observed, inferred, or projected continuing decline in number of populations? Three populations at WIFN are presumed extirpated.	Yes
Is there a projected continuing decline in number of locations?	Yes
Is there an observed, inferred, and projected continuing decline in area, extent and/or quality of habitat?	Yes in quality and area
Are there extreme fluctuations in number of populations?	No
Are there extreme fluctuations in number of locations (as per definition, in terms of threat)?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

Number of Mature Individuals (in each population)

Population	N Mature Individuals
WIFN population 3	6,000
WIFN population 4	17,000
La Salle (not seen in 2008 but may persist)	0
Total	23,000

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	Unknown
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Threats (actual or imminent, to populations or habitats)

Lack of fire, encroachment by woody species, housing development, invasive species (White Sweet Clover), trampling, changes in water level
--

Rescue Effect (immigration from outside Canada)

Status of outside population(s)? U.S.: Species S1 in adjacent states Michigan and Ohio	
Is immigration known or possible?	Unknown and extremely unlikely
Would immigrants be adapted to survive in Canada?	Only in very limited areas of suitable habitat
Is there sufficient habitat for immigrants in Canada?	Very limited
Is rescue from outside populations likely?	No

Current Status

COSEWIC: Endangered (November 2010)

Status and Reasons for Designation

Status: Endangered	Alpha-numeric code: B1ab(i,ii,iii,iv,v)+B2ab(i,ii,iii,iv,v)
Reasons for designation: A highly restricted annual species of tallgrass prairie known in Canada from only two populations in southwestern Ontario. Recent losses of subpopulations have resulted in a decline in range, habitat area and quality, and number of mature individuals.	

Applicability of Criteria

<p>Criterion A (Decline in Total Number of Mature Individuals): Not applicable. No obvious continuing decline of sufficient magnitude.</p>
<p>Criterion B (Small Distribution Range and Decline or Fluctuation): Meets Endangered B1ab(i,ii,iii,iv,v)+2ab(i,ii,iii,iv,v) with EO and IAO within criterion limits, the presence of only two extant locations, and declines in EO, IAO, area and quality of habitat, number of locations and number of individuals. Extreme fluctuations have not been documented.</p>
<p>Criterion C (Small and Declining Number of Mature Individuals): Not applicable. Total population size exceeds criterion limits.</p>
<p>Criterion D (Very Small Population or Restricted Distribution): Meets Threatened under D2 with only two locations (if the La Salle population is still extant) with a maximum IAO of 20 km² and the presence of a variety of ongoing threats from which it can be inferred that additional small subpopulations are at risk based on past losses at WIFN.</p>
<p>Criterion E (Quantitative Analysis): None available</p>

PREFACE

The 12 occurrences recognized in the last COSEWIC update report by Canne-Hilliker (2000) have been grouped into six populations to reflect the current manner of recognizing populations, generally a separation of 1 km between occurrences. Only two of three populations, representing nine stands formerly recognized, remain extant on Walpole Island. The two populations on Squirrel Island are no longer extant. The population at La Salle, seen in recent years, was, however, not observed in 2008 and may be extirpated. Loss of habitat is ongoing as a consequence of such factors as succession by woody species due to lack of adequate frequency of burns of the prairie sites, development pressures, and spread of invasive plants.



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 (2010)

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.



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

COSEWIC Status Report

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Skinner's Agalinis *Agalinis skinneriana*

in Canada

2010

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and classification

Scientific Name: *Agalinis skinneriana* (Wood) Britt. Britton and Brown, Illustrated Flora of northeastern United States, ed. 2 (3): 212, fig 3828. 1913.

Synonyms: *Gerardia skinneriana* Wood Class-book. ed. 2, 408. 1847.
Aureolaria skinneriana (Wood) Farw. Annual Rep. Michigan Acad. Sci. 20: 190. 1919.

Common Names: Skinner's Agalinis, Skinner's False Foxglove, Skinner's Gerardia, Skinner's-foxglove, Pale False Foxglove, Pale Gerardia, Skinner's Pale Purple False Foxglove, Midwestern Gerardia, Gérardie de Skinner.

Family: Orobanchaceae (formerly in the Scrophulariaceae)

Major plant group: Eudicot flowering plants

The genus *Agalinis* was formerly included in the Scrophulariaceae, but recent phylogenetic analysis of parasitic members of the Scrophulariaceae and Orobanchaceae based on sequences of the plastid gene *rps2*, show that parasitic members of Scrophulariaceae and Orobanchaceae form a monophyletic group in which parasitism can be inferred to have evolved once (dePamphilis *et al.* 1997; Olmstead *et al.* 2001). ITIS (2008) still lists the species as a member of the Scrophulariaceae.

There has been (and remains) considerable confusion over the differences between *A. skinneriana* and *A. gattingeri*. The two species are morphologically similar and sympatric over much of their range and have sometimes been treated as a single taxon (e.g., Holmgren 1986; Canne-Hilliker 1988). Currently they are treated as distinct species by most authors (e.g., Morton and Venn 1990; Voss 1996; Kartesz 1999; NatureServe 2009). Genetic analysis supports this separation (Pettengill and Neel 2008).

The original generic name *Gerardia* L. has been rejected in favour of *Agalinis* Raf. because the former was based on a type specimen from the Acanthaceae (Stafleu 1978).

Morphological description

Agalinis skinneriana is a small, slender, annual, hemiparasitic herb that may reach 65 cm in height. The stem is usually simple or with a few ascending branches in the upper part, square in cross-section with stiff corners, and slightly rough on the angles (Figure 1). The leaves are more or less opposite, sessile, linear, up to 2 mm wide and 20 mm long. Both the leaves and stem are a yellowish green, suffused with purple late in the season, but drying green. The roots are branched, and develop small haustorial attachments to neighbouring plants. The inflorescence is a raceme, with usually one, but sometimes two flowers per node. The pedicel is 5-20 mm long, sometimes becoming longer in fruit, up to twice the length of the subtending bract. The calyx is cup-shaped, hairless, 2-3.5 mm long with triangular lobes about 1 mm and reticulate venation that is not always obvious, especially in fresh material. The corolla has been described as pale pink to white with pale yellow lines and pink dots in the throat (e.g., Canne-Hilliker 1988; Gleason and Cronquist 1991; Voss 1996), but the flowers of plants at Walpole Island First Nation seem to be almost uniformly white, sometimes with a very pale flush of the faintest pink (Figure 2). The petals are united into a cup-shaped throat with spreading lobes. The margins of the lobes are ciliate, but the surfaces of the corolla lobes are hairless. Capsules are roundish, about 4-5 mm in diameter and split open at maturity. The seeds are brownish yellow, triangular, and covered with a reticulate seed coat. In combination the white flowers and upright growth form easily distinguish *Agalinis skinneriana* from all the other slender species of *Agalinis* in Ontario. *Agalinis gattingeri* has pale pink flowers, a more branched, open growth form and an irregular inflorescence. There is a band of hairs on the inside of the corolla lobes (Jones, pers. comm. 2009). *Agalinis tenuifolia* has pink or purple flowers and dark brown seeds. The foliage tends to be darker green which blackens on drying.

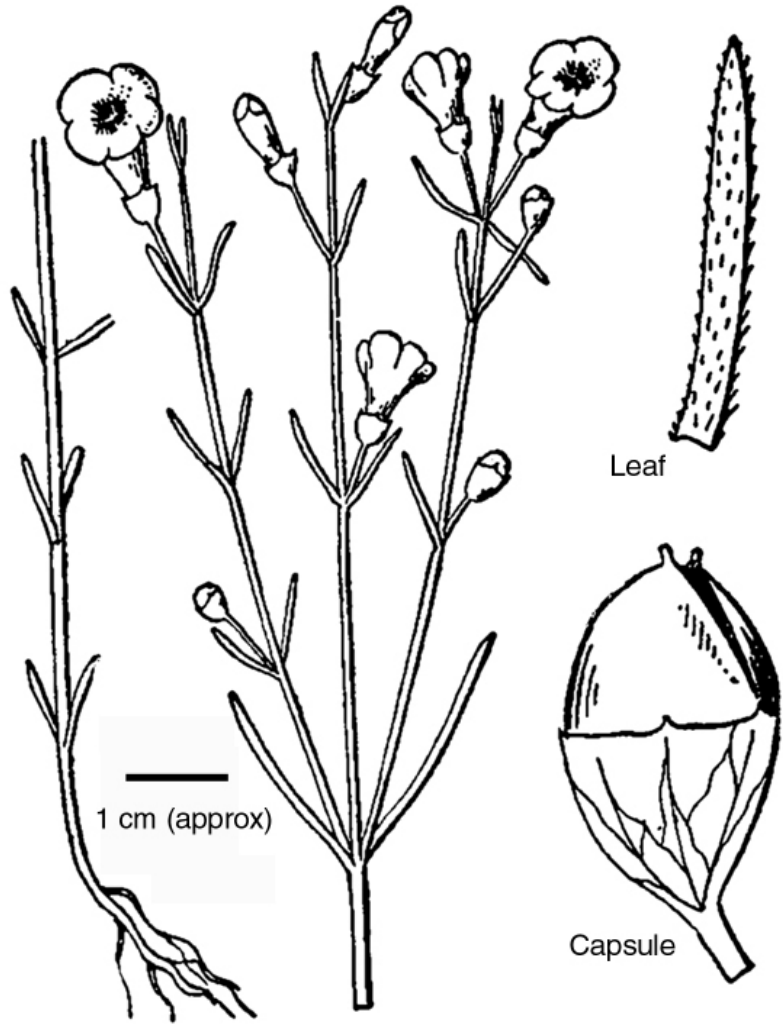


Figure 1. Line drawing of *Agalinis skinneriana*. Taken from USDA-NRCS PLANTS Database / Britton, N.L., and A. Brown. 1913. Illustrated flora of the northern states and Canada. Vol. 3: 212. Wikimedia Commons, Public Domain (USDA).



Figure 2. Photograph of *Agalinis skinneriana* flowers. Photo: Jane M. Bowles.

Population spatial structure and variability

The chromosome number of *Agalinis skinneriana* is $2n = 26$ (Canne 1984). Pettengill and Neel (2008) did a genetic analysis of chloroplast and ribosomal DNA. They found strong statistical support for the monophyly of the 29 North American *Agalinis* species they sampled, relative to outgroup species. They found that *A. skinneriana* formed a well supported clade that was sister to the clade containing *A. tenella*, *A. decemloba*, and *A. acuta*. Prior to their work, the taxonomic boundaries and phylogenetic affinities of *A. skinneriana* were not understood.

Pennell (1928, 1929, 1935), whose treatment was later supported by Canne (1979, 1984), placed *A. skinneriana* in section Erectae based on corolla form and pubescence patterns, seed colour and surface patterns, and stem and leaf anatomy. Subsection Pedunculares was considered to be distinct from the Erectae on these characteristics. Pettengill and Neel (2008) used DNA analysis to support membership of *A. skinneriana* in section Erectae, but also to align the Pedunculares and the Erectae. This alignment supports an earlier proposal by Neel and Cummings (2004). Aligning these sections unites all the *Agalinis* taxa with 13 chromosomes, with the exception *A. gattingeri*, which they placed with species considered to be in Section Purpureae. If it were not for the problematic placement of *A. gattingeri*, it would appear that $n = 14$ was ancestral for *Agalinis* and the haploid chromosome number of 13 arose only once in the genus.

Designatable units

Designatable units are not recognized because no infraspecific taxa are recognized and the species occurs within a very restricted geographical area within a single COSEWIC Ecological Area (Great Lakes Plains).

Special significance

There are no known economic or ethnobotanical uses for *Agalinis skinneriana*. This species, like others in the genus, is of special biological interest because of its hemiparasitic nature. Because of its hemiparasitism, it is not easily cultivated. Although its flowers are attractive, they are small, pale-coloured and last only half a day, and the plant is therefore unlikely to be a candidate for horticulture.

DISTRIBUTION

Global range

Agalinis skinneriana is restricted to central and eastern North America and is most frequent in the Midwest and south-central United States. It has been recorded in Arkansas (historic only), Illinois, Indiana, Iowa, eastern Kansas, Louisiana, Maryland, southeast Michigan, Mississippi, Missouri, Ohio, and Wisconsin, as well as southwestern Ontario (Figure 3). Reports from Kentucky, Oklahoma, Nebraska, and Tennessee are unconfirmed, but suitable habitat exists at least in Kentucky and Tennessee (NatureServe 2009). Although the species has been recorded from 10 states, most of the U.S. population (>70%) occurs in Missouri. The Maryland populations were beyond the known range for the species at the time they were discovered and there was some question as to their identity. Pettengill and Neel (2008) confirmed that Maryland plants are sister to the *A. skinneriana* sample from Missouri. The Maryland population therefore represents an extension of this Midwestern prairie taxon to the grasslands of the Atlantic Coastal Plain.



Figure 3. Global range of *Agalinis skinneriana* adapted from Canne-Hilker, 1998.

Canadian range

In Canada, *A. skinneriana* has only been recorded from Ontario, where it is known from Walpole Island First Nation (WIFN) and from the City of La Salle, near Windsor (Figure 4).

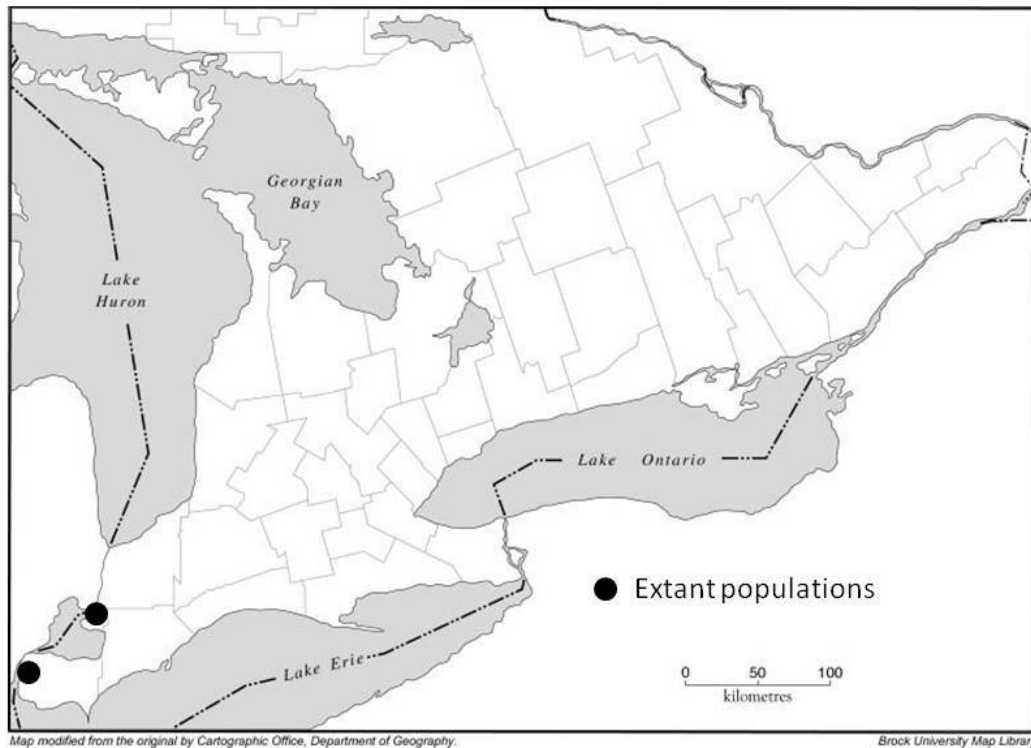


Figure 4. Map of southern Ontario showing location of Skinner's *Agalinis* populations in Ontario and Canada. Basemap modified from: St. Catharines sontbase. St. Catharines, Ontario: Brock University Map Library. Available: Brock University Map Library Controlled Access <http://www.brocku.ca/maplibrary/images/stcathv8.jpg>. (Accessed November 2, 2008.)

The extent of occurrence is approximately 70 km² including all the land, but not the water between WIFN and La Salle. The total number of 1x1 km grid squares occupied by all known populations of *A. skinneriana* at WIFN is 11, and at La Salle is 1, for a total index of area of occupancy (IAO) of 12 km² in Canada. The number of 2 x 2 km grid squares occupied is 4 at WIFN and 1 at La Salle for a total of 20 km². The actual area occupied by plants on the ground is approximately 4.3 ha (about 0.4% of the IAO).

A convex polygon drawn around extant populations at WIFN (Populations 3 and 4) encompasses approximately 59 ha, so the 4.3 ha that *Agalinis* stands actually occupy is about 7% of this. Only two stands (one in each of the extant populations) are greater than 1 ha in extent. Distances between stands are 570 m and 620 m in Population 3 and 800 m and 1000 m in Population 4. The two populations are approximately 4.7 km apart.

The normal long-term seed dispersal distance for *Agalinis skinneriana* is unknown, but is probably on the order of metres or tens of metres, not kilometres. Distances between stands are therefore much greater than normal dispersal distance of the species and there is minimal likelihood of seeds moving from one stand to another. The intervening landscape is mostly unsuitable habitat (agricultural fields, residences, roads and woodlands). Four of the six stands in the two extant populations are under 1 ha in area and three have fewer than 1000 individuals at any count. Dieringer (1999) found evidence for evolved changes in breeding morphology and breeding systems of *A. skinneriana* plants in a population of less than 1000 individuals, which may be a clue to a viable population size.

Search effort

Even though the prairies of WIFN (Woodliffe and Allen 1996) and Ojibway Prairie Nature Reserve have been well surveyed, it is possible that not all extant populations of *Agalinis skinneriana* are known at these sites. The plants are often small (less than 20 cm tall), slender and difficult to see among prairie vegetation, particularly once the flowers have fallen in the afternoon. Because of its white flowers it is easily recognized and not likely to be overlooked by botanists when it is in flower. One new stand within Population 4 was found in 2008 and other stands and even populations may have been missed at WIFN. Suitable habitat exists in other places at both WIFN and at Ojibway Prairie Nature Reserve. Because of the restricted habitat requirements it is unlikely that populations of *Agalinis skinneriana* exist elsewhere in Ontario.

HABITAT

Habitat requirements

Throughout its range *Agalinis skinneriana* grows in dry to mesic prairies, in open woods on shallow soil over limestone, chert and granite, in open rocky glades, bluffs, barrens and in pockets among dunes (Canne-Hilliker 1988). All the Canadian populations grow in mesic to moist prairies. The WIFN sites are all in Tallgrass Prairie sites on sandy loam. White (2009) found the following common species associates (in decreasing order of abundance): Little Bluestem (*Schizachyrium scoparium*), Switch Grass (*Panicum virgatum*), Hispid Goldenrod (*Solidago hispida*), sedges (unidentified to genus or species), Dense Blazingstar (*Liatris spicata*), Big Bluestem (*Andropogon gerardii*), Prairie Loosestrife (*Lysimachia quadrifolia*), Scouring Rush (*Equisetum hyemale*), Heath Aster (*Symphotrichum ericoides*) and Black-eyed Susan (*Rudbeckia hirta*). Of these associates, sedges, as well as *Solidago hispida* and *Rudbeckia hirta*, were found as nearest neighbour species (and thus the most likely host for the hemiparasite) more often than would be expected from their overall abundance, although *Schizachyrium scoparium* was the most frequent nearest neighbour overall. *Panicum virgatum* was a nearest neighbour less often than expected by chance.

Personal observations by Bowles, Jacobs and White suggest that, on a micro-habitat scale, plants grow more abundantly in slightly low-lying areas and shallow swales and areas where the topsoil has been scraped away during drainage operations. Plants are most often found in patches where the height of vegetation (usually prairie grasses) is lower and there is some bare soil surface. Frequently, *A. skinneriana* appear clustered around the base of clumps of grasses, particularly Little Bluestem.

Habitat trends

Tallgrass prairies throughout North America have declined dramatically since European settlement (Rodger 1998). Many of the prairies at WIFN are in excellent condition. Some areas have never been ploughed and regular burns occur (Bowles 2005). *Agalinis skinneriana* is found on two of the largest of these prairie remnants. In Ontario, where rainfall is abundant, and without fire to suppress tree growth, prairies can quickly change to savannah and savannah to woodland. This is particularly true on WIFN where the water table is relatively high (Woodliffe and Allen 1996; Woodliffe 2002). Some prairies may have expanded since First Nations started maintaining a permanent settlement on the islands in the early 1800s, but many areas have been lost to agriculture, development and encroachment by woody species. In the 25-year period between 1972 and 1998, air photos suggest that prairies at WIFN were reduced from about 730 ha to about 470 ha, a loss of 36% (Crow *et al.* 2003). Some of this was a result of conversion to agriculture and housing, but most was due to encroachment by woody species in the absence of regular fires and loss of grazing by herds of wild horses.

Losses of potential habitat for *Agalinis skinneriana* continue as a result of ongoing housing development, conversion to agriculture and encroachment by woody species. The frequency of fires on WIFN prairies has decreased as housing has expanded. One site for *Agalinis skinneriana* was affected by flooding due to a combination of high lake levels and changes in drainage for development.

At La Salle, encroachment by woody species, including the growth of planted Scots Pine (*Pinus sylvestris*) trees, has degraded the habitat for *A. skinneriana*.

BIOLOGY

Life cycle and reproduction

Agalinis skinneriana is an annual that flowers, in Ontario, from August to late September. The flowers are ephemeral, usually falling by midday on the day they open, although some will last until mid-afternoon. Dieringer (1999) suggested this species is bee-pollinated in Illinois but is able to self-pollinate at a potentially high rate (70-100% of flowers isolated from insect pollinators). Self-pollination rates were higher in a small population than in a population with over 1000 individuals. Insects seen visiting flowers of *Agalinis skinneriana* in Illinois included bumble bees (*Bombus pennsylvanicus*,

Bombus impatiens) and solitary bees (Hymenoptera sp.), but insect visitors were seen only at the large population (Dieringer 1999). Trick (1995) recorded the Orange Sulphur (*Colias eurytheme*) and honey bee (*Apis mellifera*.) visiting in Wisconsin. The only insect visitors noted on WIFN have been solitary bees (Figure 5). It is possible that having white flowers that are open by first light, the plant is also visited by nocturnal moths, but this has not been recorded. Dieringer (1999) suggested that self-pollination is delayed until the corolla, with stamens attached, falls from the plant and passes over the receptive stigma. Flowers examined at opening had no evidence of having been fertilized.



Figure 5. Photograph of Skinner's Agalinis flower being visited by a bee. Photo: Jane M. Bowles.

Dieringer (1999) also found that the amount of pollen per flower and pollen viability were lower at the small population where the selfing rates were higher. He suggested that low pollen-to-ovule ratios and smaller flowers in a small population might indicate an evolved response to increased selfing in small populations where pollinator visits are rare.

The seeds of *Agalinis skinneriana* are very small; 100 air dried seeds weigh about 0.0035 g. In germination experiments (White 2009), seeds cold moist stratified at 5°C for 60 days had 18% germination after 7 days of incubation with a 16/8 hour light/dark light regime and a further 3% germination over the next 7 days. This corresponds to the 20% germination found by Canne-Hiliker (1988). Dark-incubated seeds had only 3% germination in the same time period. Less than 2% of seeds incubated without cold stratification germinated. Seeds that were cold moist stratified, planted in potting soil, and kept in a greenhouse germinated after about 14 days, but grew very slowly. Seeds started in the greenhouse in February began to flower in May and continued flowering into October.

White (2009) found that as seeds germinate the tip of the radical appears, followed by a brief lengthening of the hypocotyl. A distinct ring of hypocotyl hairs develops at the base of the hypocotyl and the root emerges through the ring. Although Canne-Hiliker (1988) examined seedling morphology, including hairs in several species of *Agalinis*, she did not include *A. skinneriana* in this study and did not note hypocotyl hairs in any other species. An initial stage of seed germination in graminoids is the formation of coleorhizal hairs, which adhere to the substrate surface and assist in seed orientation and root penetration into the substrate. A similar role for hypocotyl hairs has been described for *Artemisia tridentata* (Young and Martens 1991), *Melaleuca ericifolia* (Robinson *et al.* 2008) and *Angelonia salicariifolia* (Moro *et al.* 2001), but generally hypocotyl hairs are rarely reported. Morita *et al.* (1995) studied hypocotyl hair development and root penetration in several species in different families and found that root penetration of the substrate was faster in species that developed hypocotyl hairs. Hypocotyl hairs were only produced in plants with very small seeds (in which 1000 seeds had a mass of <1 g). They proposed that hypocotyl hairs were important for plants growing in grasslands where the hardness of the soil surface was high. The development of hypocotyl hairs may be important for an annual grassland species such as *Agalinis skinneriana*.

Physiology and adaptability

No data are available.

Dispersal

The small (about 1 mm) seeds of *Agalinis skinneriana* with their reticulate pattern of ridges on the surface have no obvious mechanisms for long-distance dispersal. Likely, short-distance dispersal occurs when seeds are shaken out of the capsules by wind, and seeds may float and be carried short distances in surface runoff during summer thunderstorms. This may help account for the concentration of plants in shallow depressions.

Interspecific interactions

Agalinis skinneriana is hemiparasitic, producing specialized root structures (haustoria) that attach to the roots of host species. Hemiparasites have leaves that perform photosynthesis but their roots have parasitic attachments to host species. Members of the genus *Agalinis* have a diverse number of host species, including several graminoids (grasses and grass-like plants) (Riopel and Musselman 1979; Baird & Riopel 1984; Trick 1995; Voss 1996). White (2009) extracted the roots of several plants of *A. skinneriana* to trace haustorial connections back to the host plant, but confirmed only a single connection with Little Bluestem.

No herbivory has been noted on the vegetative parts of *Agalinis skinneriana*, but about 13% of capsules were found to have been emptied by the larvae of an unknown insect.

POPULATION SIZES AND TRENDS

Sampling effort and methods

The WIFN populations are monitored as part of the Species at Risk program at the Walpole Island Heritage Centre (WIHC). All known populations were censused in 2003 and one site was censused again in 2006. Censuses consisted of walking back and forth across known sites and recording the GPS waypoints and the number of individuals at each GPS waypoint and the approximate area the plants occupy. Most of these censuses have been carried out by Bowles, Jacobs and White with assistance from staff of the WIHC. Records of exact search hours have not been kept, but have involved four dates in 2003 and one in 2006. During 2008, searches were made by six people for all or part of seven dates between August 18 and September 19, for a total of 11 person days.

At La Salle, a search was made by Bowles for about two hours on 2 September 2008.

Abundance

Canne-Hilliker (1988, 2000) reported 12 populations of *Agalinis skinneriana*, one in Essex County (at La Salle) and 11 on WIFN lands. The WIFN stands have now been grouped into five populations (see Table 1) based on a distance of more than 1 km between populations. This distance is generally used in recognizing separate occurrences/populations in COSEWIC vascular plant reports and Natural Heritage Information Centre records. Based on this revised distinction of populations, historically there have been 6 populations in Ontario. Extirpations of entire populations in the last approximately 10-20 years may include WIFN Populations 1 and 5 that have not been seen since 1997 and 1985 respectively and WIFN Population 2, likely extirpated due to land use change. However suitable habitat exists at Population 1 and several other

species at risk previously thought to have been extirpated at this site because of high water levels in the 1980s and 1990s have recently been recorded there (Walpole Island Heritage Centre, unpublished data).

Table 1. Summary of historic and current records and population estimates for Skinner's Agalinis in Canada.

Population	Stand #	1987 Canne-Hilliker	1997 Canne-Hilliker	2003 WIFN	2008 WIFN
1	1	250-300	"several dozen"	No plants found	No plants found
	2	12	Extirpated		
2	11	"a few"	No plants found	No plants found	No plants found
	3	15	Extirpated	Extirpated	Extirpated
3	4	"several hundred"	"several hundred"	No plants found	90 (partial search)
	5	"several thousand"	"several thousand"	1400 (2003) 2100 (2006)	780
	7	"locally abundant"	"hundreds"	No plants found	5000
	8	"only a few"	Extirpated	Likely extirpated ?	Likely extirpated ?
4	6	"at least 1000"	"hundreds"	3200	17000
	10	"several"	Not seen, possibly extirpated	No plants found	No plants found
	13		New in 2008		40
5	9	Not seen since 1985	Not seen	No search	No plants found
La Salle	12	"a few hundred"	Not checked	-	No plants found

Only two confirmed extant populations remain on WIFN lands in 2008 and possibly one at the La Salle site. No plants were found at La Salle site in 2008, although some were present prior to this date (Paul Pratt, pers. comm. 2008); the status of this population is uncertain. Considering the various threats at the remaining populations on WIFN and the La Salle site, there are likely fewer than five locations based on the various threats and possibly as few as two.

In 2008, the number of flowering plants estimated to occur in the Canadian population was about 6000 in 3 stands in Population 3 and about 17,000 in 2 stands in Population 4 (Table 1).

Potentially other subpopulations/stands may exist on WIFN lands because plants can be difficult to see within tall grass prairie habitats.

Fluctuations and trends

Population trends are difficult to estimate because accurate counts were not made for any population before 2003. Canne-Hilliker describes abundances in such terms as “a few hundred” and “a few thousand” (Table 1). In addition, because *A. skinneriana* is an annual, the number of individuals is likely to fluctuate from year to year. Two stands in extant populations at WIFN have been eliminated because of land use change and one small population known in the late 1980s is probably extirpated. Plants at two other populations and one stand of an extant population have not been seen since the Canne-Hilliker survey in 2000; however, suitable habitat exists at these sites. Although the numbers of mature individuals may be low, it is more likely that the plants have been overlooked rather than extirpated.

At sites where plants have been counted at least twice since 2003 (Stands 5, 6 and 7, in Table 1), no consistent trend in population size emerges. Stand 5 (Population 3) had about 1,400 plants in 2003 and about 2,100 in 2006, but only 780 in 2008. No plants were seen in Stand 7 (also in Population 3) in 2003 although this site was visited on a number of occasions during surveys for this and other species. In 2008, about 5,000 plants were mapped and counted at Stand 7. In Population 4, about 3,200 plants were censused in 2003, but about 17,000 plants were present in 2008.

It is possible that the wet summer of 2008 created ideal germination and growth conditions for *Agalinis skinneriana* and this would account for the large numbers of plants seen at Stands 6 and 7. At Stand 5, the numbers of *Agalinis skinneriana* as well as other species at risk (*Polygala incarnata*, *Solidago speciosa* and *Liatris spicata*) was lower than normal, and it is likely that a late spring burn at this site affected the populations of several species in 2008. The apparent absence of plants in some years within stands such as in Population 3, stand 4 (Table 1) is perhaps a reflection of search effort and/or climatic conditions. If the latter, then the re-occurrence in a subsequent year for this annual species points to the presence of a seed bank at the site and at other sites such as at La Salle where plants have been observed in recent years but not in 2008.

At La Salle, the most likely explanation for the apparent reduction (or possible disappearance) of the population is the encroachment by woody species. This site has not been burned for several years and only a small amount of open prairie habitat remains.

Rescue effect

Natural recolonization of the species, if it were extirpated from Canada, is extremely unlikely because of the limited amount of suitable habitat, the limited number of adjacent populations in the U.S. and the lack of long-distance dispersal. *Agalinis skinneriana* is only recorded from one site in Michigan, Algonac State Park in St. Clair County. This population is separated from the WIFN populations by about 5 km, including 1 km of water. Suitable habitat exists at WIFN, so plants introduced artificially could probably survive.

THREATS AND LIMITING FACTORS

The major limiting factor for *Agalinis skinneriana* in Canada is probably the decline of the tallgrass prairie habitat where it occurs. Tallgrass prairie is critically imperilled in Canada (Bakowsky 1995) and fire is extremely important in maintaining the open prairie conditions required by this species. The importance of other species such as pollinators, hemiparasitic host interactions and mycorrhizal fungi are not known.

Anthropogenic factors are important in reducing the amount of natural prairie habitat by conversion to agriculture and housing and other land uses. The rate of conversion of prairie to agriculture has been reduced on WIFN because of an active campaign by the Walpole Island Heritage Centre to lease the land for conservation, but the threat remains, especially on private land. The largest sites for *Agalinis skinneriana* at WIFN are already protected under land ownership and leasing by the Walpole Island Heritage Centre, but there is a critical housing shortage at WIFN and houses are continuously built in tallgrass prairie habitat. Some *Agalinis skinneriana* sites have been lost to housing development in the last two decades.

Direct trampling, especially from ATV traffic may also be a factor; prairies on WIFN are searched for sweetgrass by people on ATVs, and *Agalinis skinneriana* plants may get trampled when they are small seedlings and young plants. Recreational ATV riding also occurs.

Invasive species, particularly White Sweet Clover (*Melilotus alba*), are invading several *Agalinis skinneriana* sites and causing a decline in habitat quality.

All known sites for *Agalinis skinneriana* at WIFN have been burned since 2006 but not the La Salle site. Lack of fire is allowing populations of fire-intolerant, woody species to move into the habitat (Bowles pers. obs. 2008). Short annual plants with small seeds, such as those of *Agalinis skinneriana*, are particularly susceptible to loss in fire-suppressed prairies (Leach and Givnish 1996) and the frequency of fire is declining on WIFN as more houses are built. On the other hand, fire during the growing season would be detrimental to this annual species. A late spring fire in 2008 may have contributed to a reduction in the number of plants at one site on WIFN. The La Salle site and the sites with the highest population densities at WIFN have been subject to soil

scrapes in the past 40-50 years. Such activities, which remove the surface soil horizons and inhibit some plant growth, may also limit shading and competition and provide suitable habitat for *Agalinis skinneriana*.

Agalinis skinneriana may also be affected by changes in moisture regime as a result of dredging and ditching operations and natural changes in lake levels. High water levels during the late 1980s may have extirpated one population.

PROTECTION, STATUS, AND RANKS

Legal protection and status

It is listed as Endangered under Schedule 1 of the *Species at Risk Act* (SARA); general prohibitions under the Act apply for this species on federal land, including Walpole Island First Nation. Critical habitat has not yet been determined under SARA. In Ontario, it is listed as Endangered under the *Endangered Species Act, 2007* and receives species and general habitat protection.

Non-legal status and ranks

Agalinis skinneriana has a Global rank of G3G4 (vulnerable to apparently secure) and a national U.S. rank of N3 (vulnerable) (NatureServe 2009). It is widespread through much of the Midwestern and south-central U.S. states, but most populations are quite small, and it is considered rare in most of the jurisdictions where it occurs (see Table 2). It has a rank of N1 (critically imperilled) in Canada and S1 (critically imperilled) in Ontario.

Table 2. Conservation status rank for Skinner’s *Agalinis* in the United States (NatureServe, 2009).

S-rank	State
SH (historic)	Arkansas, Kentucky
S1 (critically imperilled)	Indiana, Iowa, Kansas, Maryland, Michigan, Mississippi, Ohio
S1S2 (critically imperilled to imperilled)	Louisiana, Tennessee
S2 (imperilled)	Illinois, Wisconsin
S3S4 (vulnerable to apparently secure)	Missouri
SNR (not ranked)	Alabama, Oklahoma

Habitat protection and ownership

On WIFN, most *Agalinis skinneriana* sites are on private lands held under Certificates of Possession (under the *Indian Act*). Four sites are leased for conservation purposes, including one area protected as a nature reserve. The Walpole Island Land Trust is in the process of purchasing about 23 ha that includes most of one of the larger sites and should provide permanent protection of this site from land use change. Part of one population is on Band-owned land managed by the Walpole Island Heritage Centre. All sites for Skinner's *Agalinis* on WIFN are in or adjacent to areas that have been recognized by the Band Council as Significant Natural Heritage Sites. This status provides recognition, but no formal protection. The Draft Walpole Island Ecosystem Recovery Strategy (Bowles 2005) identifies general threats and actions to protect habitat on WIFN.

The La Salle site has been purchased as part of the Ojibway Prairie Nature Reserve and is a Provincial Nature Reserve that is protected under the *Provincial Parks Act* and managed with an approved Management Plan (Pratt, pers. comm. 2008).

ACKNOWLEDGEMENTS AND AUTHORITIES CONSULTED

This report was funded by Environment Canada through the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). The following individuals have been of assistance by supplying data and information for this report, their help and cooperation is appreciated: Dean Jacobs, Paul Pratt and Michael Oldham. In addition many people have assisted with census fieldwork at Walpole Island First Nation, especially the landholders who allowed access to their property and Walpole Island Heritage Centre staff who helped gather the information and provided support. Calvert Wright, Cam Williams and Leroy Altman helped with fieldwork in 2008.

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BIOGRAPHICAL SUMMARY OF REPORT WRITER

Jane M. Bowles received her PhD from the University of Western Ontario in 1980. She has over 25 years of experience as a freelance ecologist in southern Ontario, doing life science inventories, pursuing research in conservation ecology and working with species at risk. She has worked with the Walpole Island Heritage Centre on their species at risk and habitat stewardship programs since 2003. She has been a member of the Vascular Plant Specialist Sub-Committee of COSEWIC since 2002 and a member of COSSARO since 2006. She sits on the recovery teams for Wood-poppy, Lake Huron Dune Grasslands/Pitcher's Thistle, Tallgrass, Carolinian Woodlands and Walpole Island First Nation. She is an Adjunct Professor at the University of Western Ontario where she has also been Curator of the Herbarium and Director of the Sherwood Fox Arboretum since 2005.

Rachel White will obtain her honours degree in Biology from the University of Western Ontario in 2009. Part of her program included an internship in a plant pathology lab at Agriculture and Agri-Food Canada. In 2008-2009, she studied the microhabitat and host association of Skinner's *Agalinis* on Walpole Island First Nation, for her honours thesis, and participated in the 2008 census for the species.

Clinton R. Jacobs is Anishnaabe from Walpole Island First Nation – Bkejwanong Territory and has been Natural Heritage Coordinator for Walpole Island Heritage Centre (WIHC) since 1998. He is part of the team of the WIHC's Natural Heritage Program, which includes species at risk and habitat stewardship program. He manages species at risk monitoring, management, outreach and education programs on Walpole Island First Nation (WIFN) as well as the land securement program. He advises and supervises research activities on WIFN in collaboration with various universities. He is familiar with all populations of plant species at risk on Walpole Island and supervises field crews who conduct monitoring and census. He is well recognized in the community and has ongoing regular contact and communication with landholders. He has reviewed and commented on numerous single species recovery strategies. He sits on the Walpole Island Ecosystem Recovery Team.

COLLECTIONS EXAMINED

No herbarium collections were consulted during the preparation of this report.