COSEWIC
Assessment and Status Report

on the

Lakeside Daisy
Hymenoxys herbacea

in Canada

THREATENED
2002

COSEWIC
COMMITTEE ON THE STATUS OF
ENDANGERED WILDLIFE IN
CANADA

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COSEWIC
Assessment Summary

Assessment Summary – May 2002

Common name
Lakeside Daisy

Scientific name
Hymenoxys herbacea

Status
Threatened

Reason for designation
A Great Lakes endemic of global importance, geographically restricted to two shoreline regions of very restricted and provincially rare alvar habitats with large populations subject to risks from natural herbivores and increasing recreational use of its habitat.

Occurrence
Ontario

Status history
Designated Threatened in May 2002. Assessment based on a new status report.

COSEWIC
Executive Summary

Lakeside Daisy
Hymenoxys herbacea

Species information

Hymenoxys herbacea (E.L. Greene) Cusick, Asteraceae, is a small, perennial plant that consists of one or more low-lying rosettes (up to 10 cm in height). The mature leaves are dark green, moderately hairy and have a thick cuticle that is interrupted by numerous stomata. From a floral meristem initiated in the fall, *H. herbacea* produces a solitary inflorescence in spring, which consists of bright yellow ray (female) and disk (hermaphrodite) florets (De Mauro, 1988).

Distribution

Hymenoxys herbacea is a rare endemic of the Great Lakes region with two known extant natural populations in the United States — Marblehead Quarry, Ohio (De Mauro, 1993) and Mackinac County, Michigan (Voss, 1996). It has been introduced, through three restoration efforts, in Will County and Mason County, Illinois after being extirpated there. It has also been introduced to Kelley's Island, Ohio, in western Lake Erie, a site where it never occurred naturally (Schneider and Windus, 1993). In Canada, 38 populations are currently known from two large, relatively undisturbed regions in Ontario — the Bruce Peninsula and southern Manitoulin Island (Catling, 1995).

Habitat

Hymenoxys herbacea is most commonly found in alvar habitats, although it occasionally occurs in prairies (extirpated Illinois sites) and cliffs (Bruce Peninsula); see De Mauro, 1993; Voss, 1996; Wunderlin, 1971. The soil is sparsely distributed on top of dolomite or limestone bedrock, and the habitat is seasonally wet in spring and fall and moderately drought-like in the summer (U.S. Fish and Wildlife Service, 1990).

Biology

Hymenoxys herbacea is a clonal perennial plant, consisting of one or more rosettes, each with a cluster of fleshy, strap-shaped leaves. Plants spread via rhizomatous growth and/or branching of the woody persistent stem (De Mauro, 1993). In Canada, it flowers from early May to early July (Johnson, 1984) and is insect pollinated; a number of different insects, including four bee species, visit the flowers

(Campbell, 2001; De Mauro, 1993). The species is self-incompatible, unable to produce seeds when pollinated by pollen from the same plant or any other genetically similar individual. When pollination is successful, seeds are produced approximately three weeks after anthesis (Campbell, 2001). Seed dispersal is accomplished primarily by gravity but may also be influenced by wind and animal grazing (De Mauro, 1993).

Population size and trends

Given the low stature of *H. herbacea* and the limited dispersal of pollen and seeds, we argue that plants separated by 75 m or so of "unsuitable" habitat are relatively isolated from one another. The genetic analysis by the senior author of 13 populations (as defined by these criteria) shows that they are indeed genetically differentiated. In fact, using conventional population genetic approaches, it was determined that populations exchange only 0.6 migrants per generation (10-20 years). Populations, defined as local concentrations of individuals, separated from other such groups by a minimum of 75 m of unsuitable habitat, range from 134 to 527,625,000 rosettes (ramets). In a survey of 13 populations, 54% had greater than 1,000 flowering rosettes and 44% had more than 5,000 flowering rosettes. The total size of the Canadian population is probably not changing appreciably; however, populations that have been monitored in the most heavily traveled areas are noticeably declining.

Limiting factors and threats

Quarrying activity and cottage construction are rapidly reducing the amount of suitable habitat available on private property, while human traffic is adding to the damage incurred in public areas (pers. obs. Campbell). There are many seemingly suitable yet unoccupied habitats (alvars and cliffs) within the geographic range of *H. herbacea*. However, it is not known whether the absence of *H. herbacea* from these locations is due to insufficient dispersal or environments that are unsuitable for establishment.

Existing protection

In Canada and the province of Ontario, *H. herbacea* receives no specific legal protection. *Hymenoxys herbacea* is listed as a federally threatened species in the U.S. and endangered in Ohio and is protected under the U.S. Endangered Species Act.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) determines the national status of wild species, subspecies, varieties, and nationally significant populations that are considered to be at risk in Canada. Designations are made on all native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fish, lepidopterans, molluscs, vascular plants, lichens, and mosses.

COSEWIC MEMBERSHIP

COSEWIC comprises representatives from each provincial and territorial government wildlife agency, four federal agencies (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biosystematic Partnership), three nonjurisdictional members and the co-chairs of the species specialist groups. The committee meets to consider status reports on candidate species.

DEFINITIONS

Species	Any indigenous species, subspecies, variety, or geographically defined population of wild fauna and flora.
Extinct (X)	A species that no longer exists.
Extirpated (XT)	A species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A species facing imminent extirpation or extinction.
Threatened (T)	A species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A species of special concern because of characteristics that make it particularly sensitive to human activities or natural events.
Not at Risk (NAR)**	A species that has been evaluated and found to be not at risk.
Data Deficient (DD)***	A species for which there is insufficient scientific information to support status designation.

* 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.

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.

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COSEWIC Status Report

on the

Lakeside Daisy
Hymenoxys herbacea

in Canada

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2002

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SPECIES INFORMATION

Name and Classification

Scientific Name:	*Hymenoxys herbacea* (E.L. Greene) Cusick
Bibliographic Citation:	Cusick, A. W. 1991. Rhodora. 93: 238-241. A. Cronquist (in Gleason and Cronquist, 1991, page 864) also published the combination *Hymenoxys herbacea* (E.L. Greene) Cronquist, but Cusick's publication predates that of Cronquist (Oldham, 1997)
Type Specimen:	"bank of Illinois Canal near Joliet", 25 May, 1864. Collector: filed at GH, no collector name but probable duplicate specimen at NY collected by W. Boott.
Synonyms:	*Actinella scaposa* Nutt. var. *glabra* A. Gray (Gray's Manual of Botany, ed. 5, p. 263, 1867). *Tetraneuris herbacea* E. L. Greene (Pittonia 3:269, 1896). Tetraneuris acaulis (Pursh) Greene *Actinea herbacea* (E.L. Greene) Robinson (Rhodora 10: 68, 1908). *Actinea scaposa* (Pursh) Spreng. var. *glabra* (A. Gray) Cronquist (Rhodora 47: 403, 1945). *Hymenoxys acaulis* (Pursh) Parker var. *glabra* (A. Gray) Parker (Madroño 10: 159, 1950).
Common Names:	Lakeside Daisy, Stemless Rubberweed (Bruce Peninsula) and Manitoulin Gold (Manitoulin Island)
Family Name:	Asteraceae, Compositae
Tribe Name:	Heliantheae
Common Family Name:	Sunflower family, Aster family
Major Plant Group:	Dicot Angiosperm

Description

Hymenoxys herbacea (E.L. Greene) Cusick, is a small perennial herbaceous plant that consists of one or more leafy rosettes each up to 10 cm in height (Figure 1). The mature leaves are dark green, moderately hairy and have a thick cuticle that is interrupted by numerous stomata. Rosettes persist throughout the winter and additional rosettes are produced vegetatively after the flowering season via rhizomatous growth and/or branching of the woody persistent stem (De Mauro, 1993). The floral buds of *Hymenoxys herbacea* form in the fall and bloom the following spring as a solitary golden inflorescence on a short stalk. In Canada, the plants flower from early May to early July (Johnson, 1984). The head is radiate with pistillate ray florets and perfect disc florets.

Figure 1. Illustration of *Hymenoxys herbacea* by Jack Wellington.

Key descriptive features

Hymenoxys herbacea differs from its closest relative, *H. acaulis* var. *acaulis*, through the lack of glandular hairs on its leaves (Cusick, 1991).

Published descriptions

The original species' description of *H. herbacea* is found in Gray (1867) under the synonym *Actinella scaposa* var. *glabra*. Other descriptions of the taxon, mostly written to indicate changes in nomenclature, are given by other authors, as described by Cusick (1991).

Similar plants in area

The most similar-looking species to *H. herbacea* on the Bruce Peninsula and Manitoulin Island is *Coreopsis lanceolata* L., from which *H. herbacea* can be distinguished by its shorter stature, yellow (vs. yellow-orange) petals and earlier flowering season (*H. herbacea* starts three weeks earlier than *C. lanceolata*). In addition, *H. herbacea* has only one flowering head per scape while *C. lanceolata* may have one to a few flowering heads per peduncle and the diameter of the flowering head of *H. herbacea* is smaller (4-6 cm) than that of *C. lanceolata* (6-8 cm) (Gleason and Cronquist, 1991).

DISTRIBUTION

Global Range

Hymenoxys herbacea is endemic to the Great Lakes region (Morton and Venn, 2000). It is currently known from two sites in the United States — Marblehead Quarry, Ohio (DeMauro, 1993) and Mackinac County, Michigan (Voss, 1996) and has been extirpated from two additional locations in Illinois (Wunderlin, 1971). Currently there is a project ongoing to recreate three populations in the Illinois area (De Mauro, 1994). In Ohio, *H. herbacea* has been introduced to Kelleys Island in Lake Erie, where it never historically occurred (Schneider and Windus, 1993). A total of 38 populations is known from two large and less disturbed regions in Canada — the Bruce Peninsula, Ontario and southern Manitoulin Island, Ontario, each of which consists of several populations (Catling, 1995).

Canadian Range

In Canada, 38 extant and one extirpated *H. herbacea* populations are known from Manitoulin Island (Figure 2) and the Bruce Peninsula, Ontario (Catling, 1995; Campbell, 2001; Figure 3). This range currently extends from the western-most point on Manitoulin Island, Meldrum Bay, as far east as Cabot Head, Bruce Peninsula, as far north as Meldrum Bay and as far south as the corner of Dyers Bay Road and Highway #6 on the Bruce Peninsula. On Manitoulin Island, the populations tend to be found on the southern shoreline and inland and have not been reported from the northern shoreline (Figure 2). On the Bruce Peninsula, the populations are found on the north-eastern shoreline and inland, but have not been found on the southern shoreline (Figure 3).

HABITAT

Habitat Requirements

Hymenoxys herbacea is largely confined to the grassland and pavement alvars or lakeshores in the Great Lakes regions. These habitats are characteristically flat, thin-soiled areas with prevalent dolomite and limestone rocks, sand and gravel that are sparsely vegetated (De Mauro, 1993; Voss, 1996; Wunderlin, 1971). The habitats are open, with little tree cover, and receive large amounts of sunlight. The limestone pavement that is prevalent in the area allows for good drainage. The plants primarily grow in the cracks of the limestone pavements or on tufts of low-growing vegetation (i.e. mosses). In localized areas of alvar and cliff habitats, *H. herbacea* can be a community dominant. Although in one alvar (population CH), which is thickly vegetated with grasses and sedges, *H. herbacea* is much less dense.

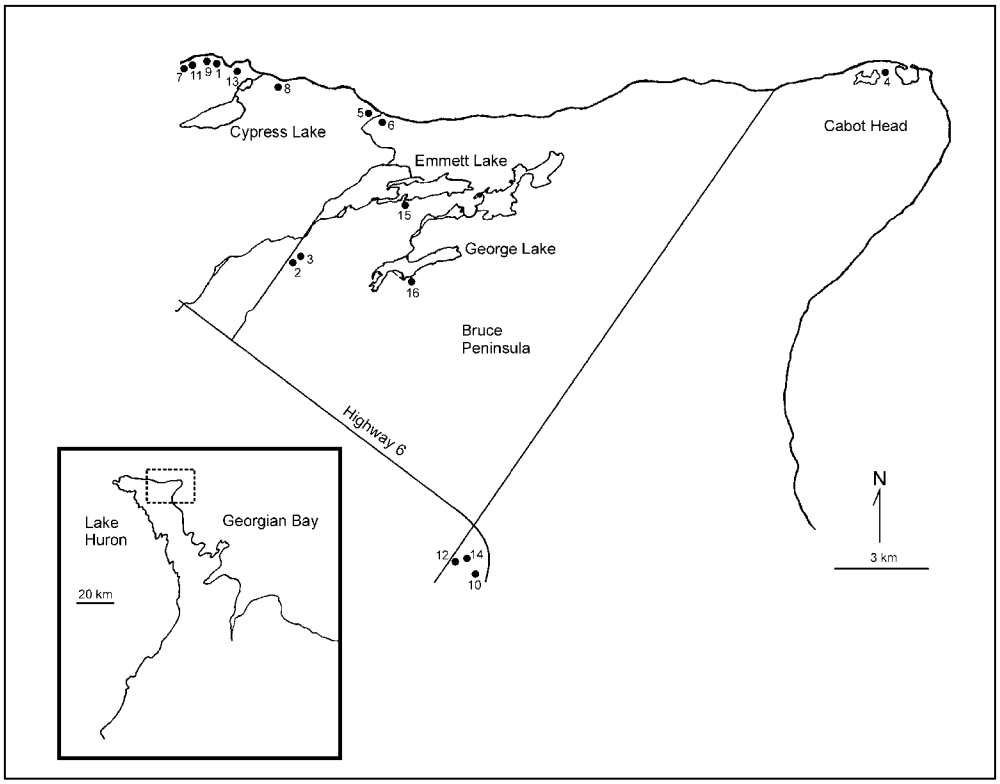

Figure 2. Distribution of *Hymenoxys herbacea* populations on Bruce Peninsula, Ontario.

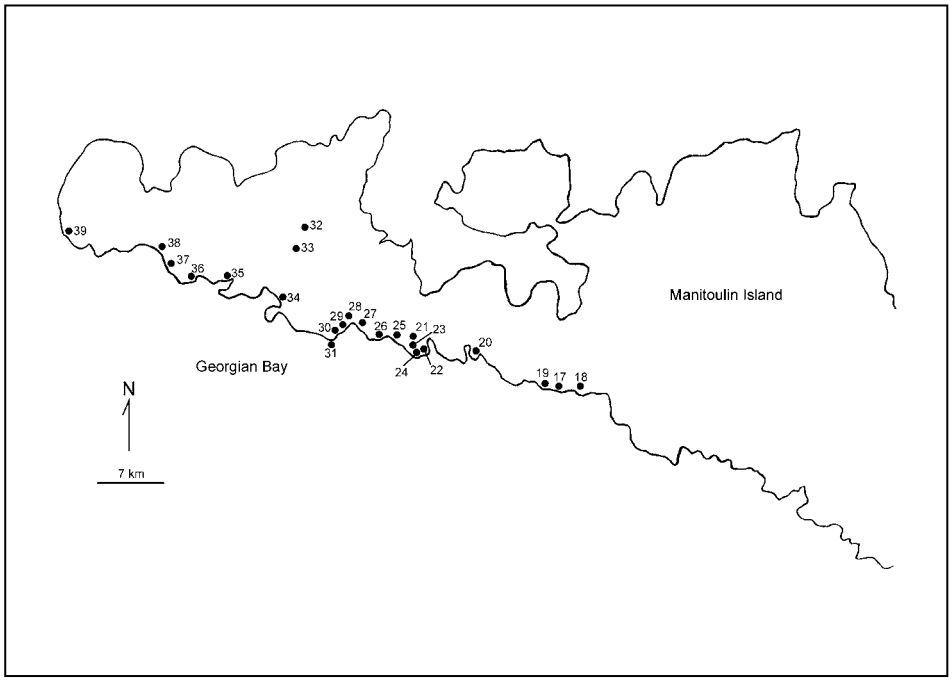

Figure 3. Distribution of *Hymenoxys herbacea* populations on western Manitoulin Island, Ontario.

Specific Habitat

Hymenoxys herbacea occurs in one of three specific types of alvar habitat as defined by Reschke *et al*. (1999). A shortened description of each habitat type is given below; for a more detailed description see Reschke *et al*. (1999).

Grassland alvars have been classified by the Alvar Working Group of The Nature Conservancy (Reschke *et al*.,1999) as a 'Little bluestem alvar grassland'. This community has a global rank of G2 (imperiled globally with usually 6 to 20 global occurrences) and is recognized by: open canopy, few shrubs over 0.5 m tall, many dwarf shrubs under 0.5 m tall, less than 50% of the ground surface is exposed and is dominated by grasses and sedges, loam soils are shallow over flat limestone dolostone bedrock, soils are often seasonally wet (saturated) and very dry (Reschke *et al*., 1999).

Non-vascular pavement alvars have a global rank of G2 and are defined as having: open canopy, few shrubs, ground layer is primarily exposed limestone or dolostone bedrock covered with lichens and mosses, and the little soil present is restricted to rock crevices (grikes), or underneath a mossy mat (Reschke *et al*., 1999).

Great Lakes limestone alvars are sparsely vegetated lakeshores found along the Great Lakes shorelines of Ontario and have exposed flat limestone or dolostone bedrock (about 20% vegetative cover). The surface of the bedrock has numerous cracks and crevices where most of the plants are rooted (Reschke *et al*., 1999).

Regional Climate

On average, the Bruce Peninsula/Manitoulin Region experiences temperatures between 0 C and +27°C during the flowering season (April to July) and between 0°C and –25°C during the winter (December to February) (Environment Canada Statistics). In the pavement and grassland alvars, there is an alternating wet and dry soil moisture regime. These locations tend to be wet in the spring and fall and very dry in midsummer. Often these locations are sheltered from the wind by surrounding forests (Reschke *et al*., 1999). On the lakeshore habitat, there is frequent fog and populations are exposed to the prevailing winds.

Regional Vegetation

The dominant species in grassland alvars are typically *Sporobolus heterolepis, Schizachyrium scoparium* or *Carex scirpoidea*. The characteristic species of the non-vascular pavement alvars are lichens and mosses (such as cup lichen, blackthread lichen, twisted moss, *Saxifraga virginiensis*, *Penstemon hirsutus, Potentilla norvegica*, and *Trichostema brachiatum*. Typically, in the limestone lakeshores of the Great Lakes, *Calamintha arkansana, Pentaphylloides floribunda, Potentilla anserina, Panicum lindheimeri, Thuja occidentalis, Deschampsia cespitosa, Viola nephrophylla, Primula mistassinica* and *Lobelia kalmii* are present (Reschke *et al*., 1999).

Associated Species

Several species of plants are frequently found within ten meters of an *H. herbacea* individual in at least one of the habitat types. Those found include:

Allium schoenoprasum
Aquilegia canadensis
Arabis lyrata
Aster macrophyllus
Astragalus neglectus
Calamintha arkansana
Campanula rotundifolia
Carex scirpoidea
Castilleja coccinea
Cerastium arvense
Chrysanthemum leucanthemum
Cirsium hillii
Cirsium pitcheri
Cladina pixidata
Commandra umbellata
Coreopsis lanceolata
Cypripedium arietinum
Cypripedium calceolus var*. pubescens*
Danthonia spicata
Deschampsia cespitosa
Elymus lanceolatus ssp*. psammophilus*
Fragaria virginiana
Hieracium pilosella
Iris lacustris
Juniperus communis
Juniperus horizontalis
Liatris cylindracea
Lobelia kalmii
Lonicera hirsuta
Medicago lupulina
Minuartia michauxii
Pellaea atropurpurea
Pentaphylloides floribunda
Phalaris arundinacea
Plantago lanceolata
Polygala paucifolia
Polygala senega
Potentilla anserina
Potentilla fruticosa
Potentilla recta
Primula mistassinica
Prunella vulgaris
Prunus pumila
Prunus virginiana
Panicum lindheimeri
Rhamnus alnifolia
Saxifraga virginiana
Schizachyrium scoparium
Senecio obovatus
Senecio pauperculus
Sisyrinchium montanum
Smilacina stellata
Solidago houghtonii
Solidago juncea
Solidago simplex ssp*. randii*
Sporobolus heterolepis
Thuja occidentalis
Tortella tortuosa
Vaccinium angustifolium
Viola nephrophylla
Woodsia oregana var. *cathcartiana*
Zigadenus elegans

Other Rare Species found Associated with H. herbacea

Alvar communities share several key characteristics, one of which is that they contain many species that are rare elsewhere in the Great Lakes basin and some are endemic to the basin. Other rare species (i.e., they are included in the NHIC's list of rare plants; Oldham 1999 and in Brownell and Riley, 2000) that were observed to be living in the same alvars as *H. herbacea* include *Iris lacustris* (G3, S3), *Cypripedium arietinum* (G3, S3), *Solidago simplex* ssp*. randii* (S3), *Astragalus neglectus* (G3G4, S3), *Solidago houghtonii* (G3, S2), *Pellaea atropurpurea* (S3), *Senecio obovatus* (S3), *Woodsia*

oregana var. *cathcartiana* (S3), *Cirsium hillii* (G3, S3), *Sporobolus heterolepis* (S3), *Liatris cylindracea* (S3), *Cirsium pitcheri* (Endangered in Canada, G3, S2) and *Elymus lanceolatus* ssp. *psammophilus* (G5T3?, S3). See Oldham (1999) for definitions of global (G-ranks) and subnational (S-ranks) conservation status ranks.

Trends

Some shoreline habitat is degrading rapidly, particularly where pedestrian traffic is high within Bruce Peninsula National Park. These areas have been trampled consistently for a number of years as the Bruce Trail and National Park trails make use of the open spaces typical of the lakeshore habitat of the plant. Likewise, alvar habitats, with their open spaces, are being converted into camping areas although at a much slower pace than the shoreline habitat.

Protection/Ownership

Sixteen of the 39 known populations of *H. herbacea* are found on privately owned land (Natural Heritage Information Centre Records; Brownell and Riley, 2000). The other 23 populations are on property owned at least in part by public agencies (e.g. Bruce Peninsula National Park, Ontario Parks) or organizations interested in the conservation of the plant and its habitat (Federation of Ontario Naturalists, Nature Conservancy of Canada, Cape Croker First Nations Band, Private Plant Reserve). Most of the privately owned properties occur on Manitoulin Island while most of the Bruce Peninsula populations exist on nature reserves.

BIOLOGY

General

Hymenoxys herbacea is a herbaceous perennial (Figure 1). It blooms from early May to early July, producing a single yellow inflorescence that is insect pollinated. Seeds are dispersed via gravity and wind vectors approximately three weeks after the inflorescence has finished blooming (De Mauro, 1993). There is no period of seed dormancy and new seedlings are produced late in the summer, during periods when the soil is moist (De Mauro, 1993). Flower buds are produced late in the summer and, as such, overwinter.

Studies of the life history of *H. herbacea* usually classify plants into one of 5 demographic stages (J. Windus, pers. comm.). These include:

1) seed - small, 5-angled, top-shaped, hairy achenes;
2) plantlet - a tiny shoot with 2 leaves and 1 narrow center leaf;
3) Juvenile 1 - single rosette, 4-6 leaves, less than 2.5 cm tall;
4) Juvenile 2 - more than 6 leaves, more than 2.5 cm tall;
5) Adult reproductive – rosette with flowering scape.

Reproduction

Modes of Reproduction

Hymenoxys herbacea plants are capable of reproducing both sexually, via a single capitulum, and asexually, via rhizomatous growth and/or branching of the woody caudex. The importance of these two modes of reproduction may vary among years and locations. However, in two populations of H. herbacea on the Bruce Peninsula, 23% of the rosettes reproduced asexually and between 12% and 24% of the population reproduced sexually over a one year period (Campbell, 2001).

Sexual Reproduction

Flowering plants produce an inflorescence (capitulum) that consists of many individual flowers (or florets) packed densely together. The number of florets per inflorescence averaged 87.2 (SE = 1.77) in 1999 and ranged from 38 to 150 (Campbell, 2001). Furthermore, coastal populations tended to have significantly more florets than those inland (t-test: t = 2.849, df= 10, p = 0.017).

Hymenoxys herbacea flowers are self-incompatible (De Mauro, 1993). Self-incompatibility is a genetically controlled mechanism whereby pollen with the same alleles as the pollen recipient plant, at the self-incompatibility gene, are recognized and rejected (de Nettancourt, 1977; Mulcahy and Mulcahy,1985). As a result, fertilization and subsequent seed production occurs only after pollinations between genetically distinct individuals. At the population level, sustained seed production requires at least 4 self-incompatibility alleles to be represented among the residents. Self-incompatibility has been confirmed through pollination experiments in 13 populations on the Bruce Peninsula and 6 Manitoulin Island populations (Campbell, 2001). Seed set averaged 0.2% in self-pollinations. This was confirmed by genetic analyses in two populations which show that 86% of all offspring were the result of cross-fertilizations (14% from self-fertilization). While mate diversity was negatively correlated with population size, in no population was seed production limited by a lack of diversity at the self-incompatibility gene (Campbell, 2001).

Seed Production

Only a subset of the available ovules in *H. herbacea* ever mature into seeds. Across the range, including U.S. populations, seed developed in 43.5% (range = 27.5 to 66.2%) of the available ovules (De Mauro, 1993; Campbell, 2001). Based on estimates of seed set and the number of florets per inflorescence, the mean number of seeds produced per inflorescence in 1999 was 42.6 and ranged from 23.8 to 59 (Campbell, 2001). Mean seed set of Bruce Peninsula populations was similar to that of populations on Manitoulin Island.

Pollen Limitation

Seed production is possibly limited by a number of ecological and genetic factors, including: 1) resource availability, 2) genetic sterility, or 3) pollen limitation (i.e. not enough

compatible pollen deposited on the stigmas). The primary concern in past studies of *H. herbacea* has been pollen limitation (De Mauro, 1993; Moran-Palma and Snow, 1997; Campbell, 2001). Measured as the proportional increase in seed set due to the addition of pollen to open-pollinated florets, pollen limitation was negligible when averaged across all 12 populations examined (mean = 0.08). In other words, overall, adding more pollen had no effect on seed set. However, pollen limitation did vary from 0 to 0.54 among populations, on a scale from 0 to 1, and seed set in supplemental pollinations was significantly higher in one of the populations (Appendix 1, population CPL). Although variation in seed set among populations cannot be fully accounted for by pollen limitation there appears to be some potential for it to occur in *H. herbacea* due to its mating system. Pollen limitation in *H. herbacea* is extremely low compared to mean pollen limitation calculated in a survey of other angiosperm species (0.40) (Larson and Barrett, 2000). In fact, *H. herbacea* had unusually low pollen limitation for a self-incompatible plant, which in general have higher pollen limitation (mean pollen limitation = 0.59 (± 0.04)) than self-compatible plants (mean pollen limitation = 0.31 (± 0.03)). Clearly, *H. herbacea* is unusual in its ability to acquire sufficient compatible pollen under its ecological conditions.

Pollinator Observations and Visitation Rates

The insect visitors of *H. herbacea* are diverse, a common feature of the insect visitors of many plants that flower in early spring (Thein *et al.,* 1983; Godley and Smith, 1981). In a recent study of 13 populations on the Bruce Peninsula a total of 41 taxa, from eight families (Hymenoptera, Diptera, Lepidoptera, Neuroptera, Homoptera, Hemiptera, Coleoptera, Orthoptera; see Table 1) were observed on *H. herbacea* flowers (Campbell, 2001); however, some of these were probably not pollinators. The number of taxa observed per 30-minute observation period averaged 2.68 and ranged from 0.86 to 5.17. However, this value was not correlated with either geographic isolation or population size (Campbell, 2001). In addition, the diversity of insects visiting each population ranged widely among populations and was negatively correlated with geographic distance to the nearest population. However, variation in insect diversity could not be linked to differences in seed set among populations (Campbell, 2001).

Table 1. List of major insect groups observed on *H. herbacea* flowers and their overall mean relative abundance on populations from the Bruce Peninsula, Ontario

Order	Mean Relative Abundance
Hymenoptera	0.1093
Diptera	0.9171
Lepidoptera	0.0096
Neuroptera	0.0001
Homoptera	0.0001
Hemiptera	0.0001
Coleoptera	0.0127
Orthoptera	0.0029

Each plant receives an average of 0.66 insect visits (SE = 0.24) per 30 minute observation period (Campbell, 2001). Plants in small populations tend to receive more visits than those in large populations. However, it is likely that not all insect visitors are effective pollen vectors. Studies of *H. herbacea* suggest that bees (Apidae, Xylocopidae and Halictidae) are particularly important for pollination (De Mauro, 1993), although flies were much more prevalent flower visitors (Campbell, 2001). In 2001, bee visitation averaged 0.08 (SE=0.04) visits/plant/30-minute observation period, and three populations did not receive any visits from bees during 57 hours of observation (populations BC, FW, HL). The importance of bees is highlighted by the fact that the degree to which plants are pollen limited increases as bee visitation decreases. In general, pollinator visitation is susceptible to the vagaries of the environment, including temperature, wind, and precipitation and visitation by insects to *H. herbacea* is no exception. In years with more extreme weather conditions, especially those not conducive to pollen dehiscence, pollinator activity may affect pollen limitation more drastically than in years with good weather conditions for insect activity (Campbell, 2001).

Mate Limitation

Reproduction in self-incompatible plants may be limited by insufficient diversity of mating types in a population. The diversity of mating types (mate diversity), measured as the proportion of crosses that are genetically compatible within a population, has been measured in 12 Canadian *H. herbacea* populations (Campbell, 2001). Roughly speaking, between 17 and 58% of all pollinations were compatible in populations on the Bruce Peninsula. These values are similar or lower than the proportion of compatible crosses in a study of an *H. herbacea* population in the U.S. by De Mauro (1993), where 58% of the within-population crosses were compatible. Mate diversity was strongly correlated with population size: as population size decreases, mating type diversity also drops (Campbell, 2001). However, mate diversity was apparently high enough in most populations as to not affect seed production (Campbell, 2001).

In summary, Canadian populations, on average, have enough pollinator activity and mate diversity to ensure that seed set is not pollen limited (Campbell, 2001). However, population size plays an important role in pollen limitation via mate diversity. Natural area managers must be aware that should the size of these populations of *H. herbacea* become smaller, pollen limitation could threaten their persistence.

Recruitment Rates

In a recent demographic study of two populations, recruitment over a one-year period occurred at a rate of 0.65 recruits per existing rosette. Of these recruits, 94% were produced via asexual recruitment and 6% were derived from sexual reproduction (Campbell, 2001).

Growth and Survival

Size Structure

Existing populations are composed of rosettes of different size and stage of development: Juvenile 1 (4-6 leaves/rosette); Juvenile 2 (>6 leaves/rosette) and Reproductive Adult (rosette with inflorescence). In a demographic study of two populations in 1999 and 2000, Juvenile 2 plants were most frequent (54 to 67% of all individuals), followed by Reproductive Adults (24 to 30%) and Juvenile 1 plants (8.8 to 15.9%) (Table 2) (Campbell, 2001).

Table 2. Demographic transition matrix for *H. herbacea* populations CPL and HL censused over a one year interval (1999-2000).

2000	1999					
	CPL			HL		
	Juvenile 1	Juvenile 2	Adult	Juvenile 1	Juvenile 2	Adult
Juvenile 1	5 (0.38)	12 (0.12)	4 (0.11)	15 (0.68)	7 (0.09)	7 (0.17)
Juvenile 2	5 (0.38)	57 (0.58)	26 (0.72)	6 (0.27)	53 (0.71)	29 (0.71)
Adult	1 (0.08)	21 (0.21)	4 (0.11)	0 (0)	14 (0.19)	1 (0.02)
Dead	2 (0.16)	9 (0.09)	2 (0.06)	1 (0.05)	1 (0.01)	4 (0.10)

Juvenile 1 individuals comprise a single rosette with 4-6 leaves; Juvenile 2 individuals have more than 6 leaves, and Adult individuals are reproductive. The first value in each cell represents the number of individuals of a particular stage in 1999 that occurred in a specific stage in 2000. The second value (in brackets) represents the proportion of individuals from 1999 that were observed in 2000. Proportions in each column sum to one.

Stage Transitions

Growth of individuals has been assessed by monitoring the changes in developmental stage over a one-year interval. From 1999 to 2000, most (53.4%) Juvenile 1 rosettes remained as Juvenile 1 plants. Of the remainder, 33% grew to become Juvenile 2 plants and 4% became Reproductive Adults. Most Juvenile 2 individuals (64.2%) remained as Juvenile 2 plants. However, 11% of Juvenile 2 plants reverted to Juvenile 1 status and 20% grew to become Reproductive Adults. Juvenile 2 individuals were the most likely of all stages to become Reproductive Adults. Over the same one-year interval, most Reproductive Adults (71.4%) reverted to the Juvenile 2 stage; only 6.8% remained as Reproductive Adults (Campbell, 2001).

Survival

Survival is generally high for *H. herbacea* plants from one year to the next. In one demographic study (Campbell, 2001), fewer than 5% of rosettes died. While survival was high for all rosettes, it tended to be higher in Juvenile 1 plants (99%) than Juvenile 2 (96.6%) and Reproductive Adult (97.8%) plants.

Population Growth Rate

Using the above information on growth, survival and reproduction, population growth rates ($\lambda = N_{t+1} / N_t$) have been estimated for two populations of *H. herbacea*. The growth rates were 0.486 for population HL and 0.903 for population CPL indicating that both populations were declining in size ($\lambda = 1$, stable population size). It is not clear how representative these estimates are for *H. herbacea* populations in general. Both of these populations are in high-use areas; population HL is on the Bruce Trail and population CPL is in an area that is relatively popular with climbing or scrambling enthusiasts.

Generation Length

Generation length (L), defined as the mean age at which new plants produce offspring (asexual or sexual) (Yonezawa, 1997), averaged 16 and ranged from 10.78 to 21.08 years (Campbell, 2001).

Movements/Dispersal

The achenes are dispersed by gravity or wind approximately four to six weeks after fertilization (DeMauro, 1993). Although dispersal distance is unknown, seedlings are most dense within one meter of adult plants (De Mauro, 1993).

Migration between populations has been measured for *H. herbacea* by examining the distribution of genetic diversity within and among populations. Based on a genetic analysis of 12 populations from the Bruce Peninsula, Ontario, migration (Nm) averaged 0.56 migrants per generation (Campbell, 2001). This is a low level of migration compared to many plants of similar life history, and could lead to significant genetic differentiation among populations.

Nutrition and Interspecific Interactions

There are two interspecific interactions that are of important consequence for *H. herbacea*: herbivory and human trampling.

Herbivory

Herbivory has been observed on the peduncles, florets, receptacle and achenes by insects, white-tailed deer, seed-eating birds and eastern cottontail rabbits. In some cases herbivory has entirely prevented seed production in affected plants (De Mauro, 1993; Campbell, 2001). The amount of herbivory likely varies among populations, regions (Manitoulin Island versus Bruce Peninsula) and years depending on the size of herbivore populations and availability of other foodstuffs. In all 7 Manitoulin Island populations visited in 1999, there was severe damage imposed by a seed-eating larva, which often reduced seed production to zero. The same damage, however, was evident in only 1 of 12 populations surveyed the same year on the Bruce Peninsula, Ontario.

Immature grasshoppers were more often observed on the Bruce Peninsula plants and were virtually non-existent on Manitoulin Island. Herbivory by rabbits was more commonly seen in inland populations while herbivory by seed-eating birds was more commonly seen in lakeshore habitats. Herbivory by rabbits, birds and deer however was much less severe than the damage imposed by larvae or grasshoppers (Campbell, 2001). The intensity of herbivory and the impact on population growth rates has not been measured quantitatively.

Trampling

Eight of the 13 populations on the Bruce Peninsula (Cypress Lake and Halfway Log Dump of Bruce Peninsula National Park) are on hiking trails and popular scrambling areas. Two populations (SC and CPL), in particular, were seen to decline in numbers over the two years of observation and, although untested, it seems likely that this is due to damage in part from human traffic. Other populations (i.e., HL or LC), however, were seemingly unaffected by human traffic. Seven of the populations on Manitoulin Island are also in heavily traveled areas; however their population sizes have not been monitored. Many populations exist on or near roads and hiking trails. It is uncertain whether the existence and maintenance of the roads affects the survival of the populations positively (maintaining open spaces) or negatively (compaction of soil and damaging the plants) (Campbell, 2001).

Genetic Diversity

The genetic diversity of *H. herbacea* has been measured using enzyme electrophoresis. All of the 13 populations sampled on the Bruce Peninsula had variation in at least one locus, with an average of 1.33 alleles per locus (Campbell, 2001). The percentage of polymorphic loci ranged from 11.11% to 44.44%, with a population average of 30.77%.

The magnitude of genetic diversity within *H. herbacea* populations was similar to that in other perennial, endemic, outcrossing, animal-pollinated plants (Hamrick, 1990). As *H. herbacea* is a self-incompatible plant and hence obligate outcrosser, populations are predicted to be relatively undifferentiated with respect to genetic variation.

Table 3. Magnitude of genetic variation within populations of *Hymenoxys herbacea* censused.

Population	# of alleles observed	P(%)	A	AP	H_N
BC	12	33.3	1.33	0.60	0.1576 (0.24)
CCL	10	25.0	1.25	0.50	0.0827 (0.17)
CCS	9	28.6	1.29	0.50	0.0876 (0.18)
CH	13	50.0	1.50	0.80	0.1591 (0.22)
CPL	12	37.5	1.38	0.60	0.1437 (0.22)
CPS	10	25.0	1.25	0.50	0.1055 (0.20)
FW	13	44.4	1.44	0.80	0.1434 (0.21)
HL	12	37.5	1.38	0.60	0.1460 (0.22)
LC	10	25.0	1.25	0.50	0.1035 (0.20)
LFON	11	37.5	1.38	0.60	0.1671 (0.24)
NW	12	33.3	1.33	0.60	0.1617 (0.25)
SC	9	12.5	1.11	0.25	0.0432 (0.12)
SFON	12	37.5	1.38	0.60	0.1052 (0.17)

Measures are based on an a survey of allozymes using cellulose acetate electrophoresis. A minimum of 15 individuals from each population were screened at 9 enzyme loci. P = Percentage of polymorphic loci; A = Mean number of alleles / locus; AP = Mean number of polymorphic alleles per locus; HN = Nei's measure of expected heterozygosity (standard error).

POPULATION SIZES AND TRENDS

Population Size

The number of flowering adults per population in 2000 ranged from 3 (population SC) to an estimated 3,540,000 (population MB). The number of rosettes per population in 2000 ranged from 50 (population SC) to an estimated 202,013,200 (population MB). Effective population size (N_e, the number of rosettes in a randomly mating population with the same degree of genetic drift) was estimated for two populations on the Bruce Peninsula and averaged 4,343.4 individuals, 43% smaller than a simple census of rosettes would indicate (Campbell, 2001). The effective population sizes of the other *H. herbacea* populations were estimated using the N_e/N ratio of 0.43 and ranged from 22 (population GL) to 86,865,676 (population MB). An effective size of 5,000 individuals is generally recommended as a minimum target to avoid loss of both neutral genetic variation and adaptive potential and to minimize the accumulation of deleterious mutations (Lande 1993, 1994). Seven of the 38 populations had (estimated or extrapolated) values lower than this rule of thumb, suggesting that most populations are not likely to experience the negative impacts of genetic drift.

Furthermore, an elasticity analysis showed that of all demographic processes, fluctuations in the survival rate of the Juvenile 2 life stage (more than 6 leaves, no

inflorescence) has the greatest impact on effective population size (Campbell, 2001). Therefore, if N_e becomes extremely low due to habitat fragmentation, conservation efforts that increase the survival rate of this life stage will likely be the most successful.

In order for a self-incompatible plant to produce offspring, a population must maintain sufficient mating type diversity. Self-incompatibility alleles are maintained through frequency-dependent selection and hence are less vulnerable to the effects of genetic drift. Byers and Meagher (1992) determined that genetic drift can severely affect mating type diversity when effective population size is smaller than 50 individuals. Only the two smallest known populations (GL, SC) had an effective size near 50 individuals (22 and 57 respectively), which indicates that genetic drift may not have a great impact on the SI allele diversity in populations as they are currently found (Campbell, 2001).

Trends

The first reported mention of *H. herbacea* on the Bruce Peninsula was in 1965 (U.S. Fish and Wildlife Service, 1990) and it is hypothesized to have spread across the Bruce Peninsula since then. If this is true, then the species has expanded its range remarkably quickly. However, it is probable that the plant did exist on the Bruce Peninsula prior to this first sighting. Since being recognized as a species at risk in the U.S., the intensity of searching for new *H. herbacea* populations has increased. From 1999 to 2000, the number of populations known to the NHIC has grown from 22 to 39. It is likely that early search efforts were not intense and communication among knowledgeable individuals poor.

Prior to 1999, little information was available on the sizes of extant populations. From 1999 to 2000, populations were observed to increase as well as decrease. In most cases the population changes were relatively small. There was no significant change in mean population size across the one-year interval and the size of each population in 1999 was strongly and positively correlated with its size in 2000 (Campbell, 2001). Three populations were observed to decline in numbers (populations SC, CPL and ML) over a 1-year period (Campbell, 2001). These three populations were relatively small initially and all experienced heavy human traffic during the past year. Populations, SC and CPL are within National Park boundaries on the Bruce Peninsula and are found on major hiking trails within the Bruce Peninsula National Park. Population ML is found in a private campground and as such experiences a large amount of traffic (both cars and humans).

One population (population EL) from the Bruce Peninsula (site #15, Figure 3) is known to have gone extinct sometime between 1995 and 1999. The habitat at this site seemed extremely wet compared to the habitat of extant populations. Otherwise there was no obvious distinction and there was little human activity. It is obvious that *H. herbacea* can withstand some traffic. Finally, seven populations have not been seen in at least thirteen years and hence, we don't know if any or all of them are extant or extinct. All of these are in extremely isolated locations and may explain our lack of knowledge.

LIMITING FACTORS AND THREATS

From the above discussion, it is apparent that a number of factors can potentially limit the population size of *H. herbacea*. Natural limits include herbivory, dispersal ability and the ability to reproduce. Insects (including grasshoppers, beetles and caterpillars), seed-eating birds, cotton-tail rabbits and white-tailed deer all consume the floral head, thereby reducing the number of seeds produced in any given year. As the plant disperses seed primarily via gravity, its ability to colonize new habitats is restricted. In order to maintain seed production, a minimum number of self-incompatibility alleles must be maintained within the population in order to maintain a minimum number of compatible mates. Native bee pollinator guilds are known to influence seed production in Bruce Peninsula populations and should their numbers decline, so too would the daisy's ability to reproduce. Finally, human activity, in the form of hikers, cottagers and quarrying companies, influences the habitat of *H. herbacea* to varying degrees. Many populations of *H. herbacea* (especially on the Bruce Peninsula) come into contact with humans on a daily basis during the summer months.

SPECIAL SIGNIFICANCE OF THE SPECIES

The Canadian populations, consisting of 38 extant populations, out of 39 documented populations, constitute about 95% of the populations existing in the world today. In the U. S., the only other country where *H. herbacea* grows, it is considered federally threatened and occurs at only two sites. *Hymenoxys herbacea* is one of very few plant species with most of its global populations in Canada.

This plant is a community dominant in many areas in which it occurs (De Mauro, 1993). The species occurs predominantly in alvars, a globally rare community type (Brownell and Riley, 2000), where it frequently associates with other globally and provincially rare species. Its pollen supports a large group of insect visitors early in the spring when other food sources are limited (Campbell, 2001).

Its locations, found in cottage country, support eco-tourism, one of North America's fastest growing recreational activities.

The species is grown as an ornamental, and roots easily from cuttings, it is most commonly listed in the nursery trade under an older synonym *Actinea herbacea* (D. Fraser, pers. comm. 2002).

EVALUATION AND PROPOSED STATUS

Existing Legal Protection or Other Status

Summary – *Hymenoxys herbacea* presently has no legal status or formal protection in Canada. It is considered very rare (G2, S2) by the National Heritage Information Centre (NHIC) at the global and provincial level (Oldham, 1999).

International Status – In 1988, *H. herbacea* was listed by the U.S. Fish and Wildlife Service as a Federally threatened species and is protected by the U.S. Endangered Species Act. In addition, the species has been listed as Endangered in Ohio since 1980. A recovery plan has been prepared for the U.S. populations (U.S. Fish and Wildlife Service, 1990), which proposes reestablishment of the species in Illinois. It is ranked globally imperiled (G2) by the Association for Biodiversity Information (2001).

National Status – In Canada, *H. herbacea* receives no legal protection, although it appears on the rare species list for Canada (Argus and Pryer, 1990).

Provincial Status – In Ontario, *H. herbacea* receives no legal protection, although it appears on the rare species list for Ontario (White and Maher, 1983; Oldham, 1999). By the NHIC, *H. herbacea* is ranked S2 (Oldham, 1999).

Assessment of Status and Authors' Recommendation

*H*ymenoxys *herbacea* is a Great Lakes endemic species found in Canada along the southern shore of Manitoulin Island and the north shore of the Bruce Peninsula, Ontario. It has a limited and narrowly defined habitat, restricted to alvars and Great Lakes shoreline. Locally, however, it is abundant and may represent one of the most numerous spring flowering perennials present in its habitat. The demographic characteristics of two populations have been monitored in detail, and both were found to be declining in size (multiplication rates < 1). However, there was no detectable difference in the number of inflorescences within populations found on the Bruce Peninsula over two successive years. The two populations monitored closely for changes in population size are found within National Park boundaries suggesting that even populations considered "protected" are at risk of declining in size. Less is known about the populations of Manitoulin Island but, in general, these populations are larger than the populations on the Bruce Peninsula. One must recognize that the nature preserves have other uses above and beyond that of diversity preservation. Much of this land is used for eco-tourist purposes as it is ideal for trails (less need to clear and make paths in alvars). With increasing public interest in nature and growing human populations, continued vigilance will be required by conservationists and land managers to assure the permanent protection of the unique alvar habitats and *H. herbacea* populations. Further, many of the populations found on Manitoulin Island exist on privately owned land, which could potentially be developed for gravel extraction or cottages.

Based on this assessment, *H. herbacea* is proposed for COSEWIC listing as a **threatened** species in Canada.

TECHNICAL SUMMARY

Hymenoxys herbacea
Lakeside Daisy

Extent and Area Information

Extent of occurrence: 75,246 km^2

Area of occupancy: about 14 km^2

Population information

Total number of individuals in the Canadian population: 471 million rosettes (ramets)

Number of mature reproducing individuals in the Canadian population: > 6.8 million flowering rosettes

Generation time: 16 years (mean age at which new plants produce offspring)

Total population trend: unknown, but some populations known to be declining

Rate of decline for total population: ____% in 10 years or three generations, _____ % decline in ____ years.

Number of known populations: 39 in Canada

Is the total population fragmented? YES

number of individuals in smallest population: 50 rosettes

number of individuals in largest population: 202,013,200 rosettes

number of extant sites: 38

number of historic sites from which species has been extirpated: 1

Does the species undergo fluctuations in numbers? not significantly

If yes, what is the maximum number? _____

minimum number? _____

Are these fluctuations greater than one order of magnitude? NO

Threats

Habitat destruction (quarry activity, cottage construction, human traffic and trampling), habitat availability.

Rescue Effect

Does the species exist outside of Canada? YES

Is immigration known or possible? NO?, ~ 0.6 migrants/generation among Canadian populations. Migration rate between Canadian and U.S. populations unknown, but highly unlikely. The two isolated U.S. populations are separated by large water bodies from suitable habitat in Canada. This species does not disperse well and propagules would be unlikely to reach suitable habitat from U.S. populations

Would individuals from the nearest foreign population be adapted to survive in Canada? Probably

Would sufficient suitable habitat be available for immigrants? YES, at least on Manitoulin Island and the Bruce Peninsula

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Michael Oldham has over 20 years' experience as a biologist in Ontario, having worked for two conservation authorities and four Ministry of Natural Resources offices since graduating from the University of Guelph with a B.Sc. in biology. He is currently Botanist/Herpetologist with the Natural Heritage Information Centre in Peterborough, Ontario, and specializes in the conservation biology of Ontario's vascular plants and herpetofauna. Mike is a member of the COSEWIC vascular plant and amphibian and reptile Species Specialist Groups and sits on Ontario's Committee On the Status of Species at Risk in Ontario (COSSARO). He has authored more than a dozen COSEWIC status reports covering birds, reptiles, amphibians, and vascular plants, as well as numerous provincial status assessment reports.

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