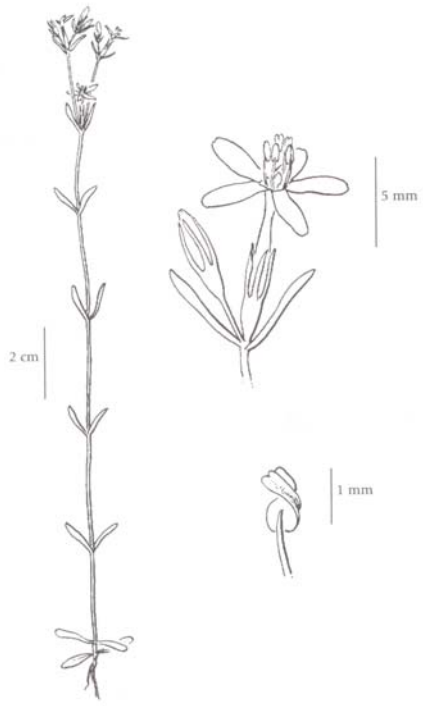
COSEWIC
Assessment and Status Report

on the

Muhlenberg's Centaury
Centaurium muehlenbergii

in Canada



ENDANGERED
2008

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. 2008. COSEWIC assessment and status report on the Muhlenberg's centaury, *Centaurium muehlenbergii* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 32 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

Production note:
COSEWIC would like to acknowledge Michael T. Miller and Wynne Miles for writing the status report on the Muhlenberg's centaury, *Centaurium muehlenbergii*,in Canada. COSEWIC also gratefully acknowledges the financial support of the B.C. Conservation Data Centre and the B.C. Ministry of Environment. The COSEWIC report review was overseen by Erich Haber, Co-chair (Vascular Plants), COSEWIC Plants and Lichens Specialist Subcommittee, with input from members of COSEWIC. That review may have resulted in changes and additions to the initial version of the report.

For additional copies contact:

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

Tel.: 819-953-3215
Fax: 819-994-3684
E-mail: COSEWIC/COSEPAC@ec.gc.ca
http://www.cosewic.gc.ca

Également disponible en français sous le titre Évaluation et Rapport de situation du COSEPAC sur lla petite-centaurée de Muhlenberg (*Centaurium muehlenbergii*) au Canada.

Cover illustration:
Muhlenberg's centaury — Line drawing from Hitchcock *et al*. 1959 and Douglas *et al*. 1999, reproduced with permission from University of Washington Press.

Catalogue No. CW69-14/554-2008E-PDF
ISBN 978-0-662-48927-6


Recycled paper

COSEWIC
Assessment Summary

Assessment Summary – April 2008

Common name
Muhlenberg's centaury

Scientific name
Centaurium muehlenbergii

Status
Endangered

Reason for designation
This small annual plant occurs in only three small areas of mainly wet habitat in southwestern British Columbia. Its total Canadian population consists of fewer than 1000 plants. These are highly disjunct from the main range of the species that extends from Oregon to California and Nevada. The species is at continued risk from such factors as the spread of invasive plants and human activities including trampling in areas used for recreational activities.

Occurrence
British Columbia

Status history
Designated Endangered in April 2008. Assessment based on a new status report.

COSEWIC
Executive Summary

Muhlenberg's centaury
Centaurium muehlenbergii

Species information

Muhlenberg's centaury (*Centaurium muehlenbergii*) is a small annual herb in the gentian family. It has opposite leaves and pink or white tubular flowers with flaring lobes, and typically grows to 4-8 cm in its Canadian habitat.

Distribution

The range of the species extends from British Columbia south to Oregon, Idaho, Nevada and California. Only three extant populations are known in Canada, all on or near southeastern Vancouver Island. There is a single population in Greater Victoria, one on the Gulf Islands, and one near Nanaimo. The species' Extent of Occurrence is 160 km^2 and its Area of Occupancy is <20 km^2. The actual total area of habitat occupied, however, is only about 110 m^2.

Habitat

Muhlenberg's centaury is found in the Coastal Douglas-Fir Biogeoclimatic Zone, where it occurs in habitats ranging from vernal pools (water only present in the spring) and seeps to the margins of a coastal salt marsh. Increasing urbanization around Victoria, combined with the draining of wetlands for agricultural uses and development, has altered the ecology of the region to such an extent that the amount of area suitable for supporting this species is now significantly reduced compared with historical levels.

Biology

Muhlenberg's centaury is an annual species; it flowers in the summer and produces several small seeds that remain dormant through the winter and germinate the following year. Some seeds probably remain dormant for longer than a year, forming a persistent seedbank, but this has not been confirmed. Little else is known about the ecology of this species, including its germination requirements, survival and recruitment rates, dispersal mechanisms, and intrinsic vulnerabilities to disturbance.

Population sizes and trends

Total population size at the three extant sites is currently estimated to be between 500 and 1000 individuals. The majority of these occur at a single site. There is no evidence of population declines in the last 10 years, and populations appear to be more or less stable.

Limiting factors and threats

The ecological factors naturally limiting the abundance and distribution of this species are largely unknown. Aside from habitat loss due to urbanization, the primary threats to its persistence in Canada are: competition from introduced species, especially grasses; trampling by people, dogs, and bicycles; off-road vehicle traffic; hydrologic alterations; altered fire regimes; and disturbance from Canada geese.

Special significance of the species

Species in the genus *Centaurium* have long been held in regard for their medicinal properties, although Muhlenberg's centaury is not known to have any such uses in Canada.

Muhlenberg's centaury may be of special interest genetically, insofar as peripheral populations are often genetically distinct from those in the core of the range. The British Columbia population of Muhlenberg centaury is about 300 km disjunct from the northern extent of its main range in California and Oregon.

Existing protection or other status designations

Muhlenberg's centaury is Red-listed in British Columbia; it has a provincial conservation rank of S1 (critically imperilled) and a national heritage rank of N1. However, there is no legal protection in place either for it or its critical habitat in Canada. The species can be added to the list of species under the B.C. *Wildlife Amendment Act* (2004) by provincial cabinet if the species is listed as extirpated, endangered or threatened in B.C. on the basis of a detailed status assessment.

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 (2008)

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

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

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

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

Environment Canada
Canadian Wildlife Service

Environnement Canada
Service canadien de la faune

Canada

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

COSEWIC Status Report

on the

Muhlenberg's Centaury

Centaurium muehlenbergii

in Canada

2008

TABLE OF CONTENTS

List of figures

List of tables

SPECIES INFORMATION

Name and classification

Scientific name:	*Centaurium muehlenbergii* (Griseb.) Wight ex Piper
Synonyms:	*Zeltnera muehlenbergii* (Griseb.) G. Mans; *Erythraea muehlenbergii* Griseb.; *C. curvistamineum* (Wittr.) Abrams; *C. floribundum* (Benth.) B.L. Rob. An alternative spelling for the specific epithet is "*muhlenbergii*" (Hitchcock and Cronquist 1973).
English common names:	Muhlenberg's centaury, Monterey centaury, June centaury
Family:	Gentianaceae (Gentian Family)
Major plant group:	Eudicot flowering plant

Centaurium is generally viewed as a taxonomically difficult genus (Cronquist *et al*. 1984; Hickman 1993; Turner 1993; Holmes and Wivagg 1996; G. Mansion, pers. comm. 2001; J. Pringle, pers. comm. 2001). Further work may be needed to clarify the taxonomic status of *Centaurium muehlenbergii.* The name *C. muehlenbergii* may have been misapplied to *C. exaltatum, C. tenuiflorum, C. davyi, C. erythraea, C. pulchellum*, and possibly three or four other species (J. Pringle, pers. comm.). However, *C. tenuiflorum* and *C. davyi* occur in California; *C. erythraea* and *C. pulchellum* are both exotic in North America with the latter only occurring in eastern Canada and the eastern U.S. G. Mansion has suggested recognition of a "*Centaurium muehlenbergii* complex" which includes *C. curvistamineum, C. floribundum,* and *C. tenuiflorum*. These three taxa are included as synonyms of *C. muehlenbergii* in Kartesz (1999). *Centaurium muehlenbergii* is the only element of this complex in Canada. Mansion also suggests a hybrid origin of *C. muehlenbergii*, involving *C. erythraea* and *C. tenuiflorum* (G. Mansion, pers. comm. 2001).

Due to the confusion around the taxonomy of *Centaurium muehlenbergii* it is difficult to ascertain which literature references to *C. muehlenbergii* pertain to the "true" rare plant, and which references have been misapplied.

Morphological description

Centaurium muehlenbergii is a small annual with pink or white flowers that blooms from June to August (Fig. 1). Plants range in height from 3-30 cm (individuals in B.C. are generally only 4-8 cm). The stems are hairless and have opposite leaves. Flowers are small and tube-shaped, with anthers that extend well beyond the edge of the tube and are thus easily visible. The flower stalk is shorter than the tube formed by the sepals, which in turn are shorter than the flower tube. Each flower produces numerous small ($<$ 0.5 mm) brown seeds (Hitchcock and Cronquist 1973, Douglas *et al.* 1999).

Two other species of centaury are recognized in B.C. Common centaury (*C. erythraea*), a Eurasian exotic, has a well-developed basal leaf cluster and the flowers are unstalked (or nearly so). Western centaury (*C. exaltatum*) which occurs only in

southcentral British Columbia and not west of the Cascades, lacks basal leaves; the flower stalk is also much longer than the sepals, and the sepals are as long or longer than the flower tube (Douglas *et al*. 1999). *Centaurium muehlenbergii* is readily distinguished from these two species on the basis of the above characteristics.

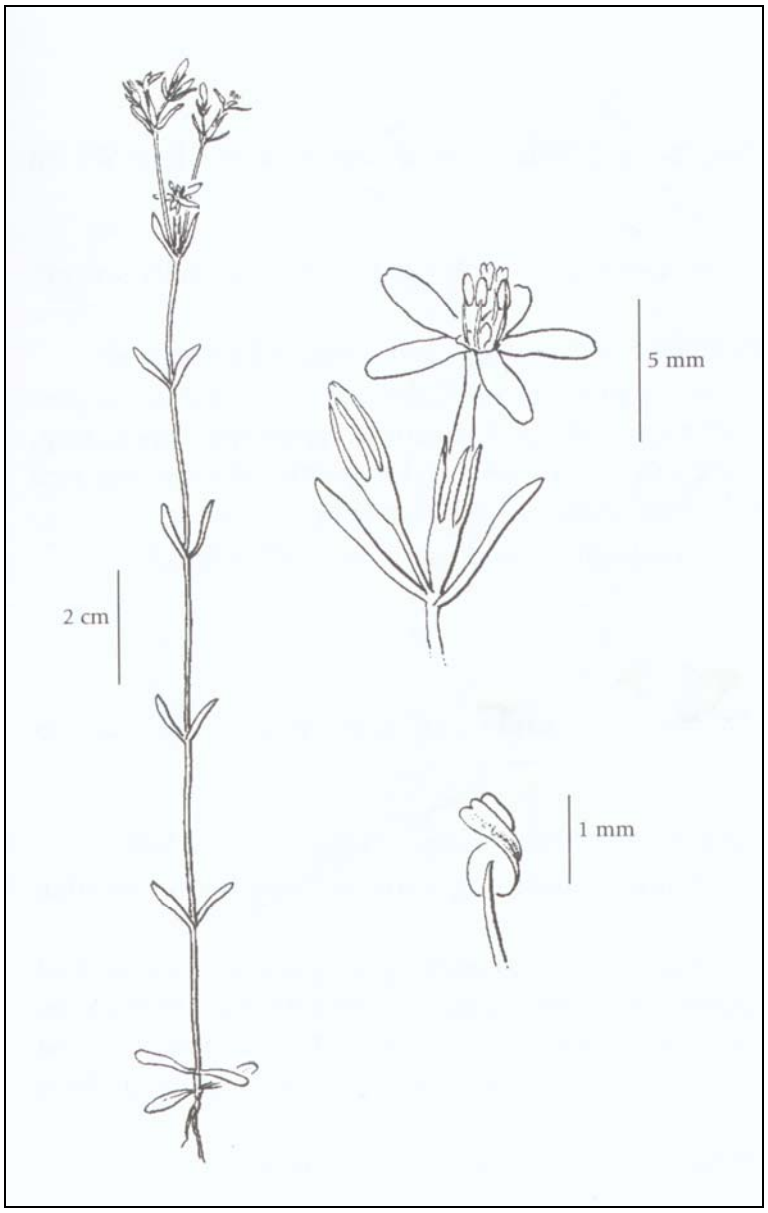


Figure 1. Illustration of *Centaurium muehlenbergii*. Shown are plant growth form, close-up of a flower and bud and of a single stamen (bottom right). Line drawing from Hitchcock *et al*. 1959 and Douglas *et al*. 1999, reproduced with permission from University of Washington Press.

Genetic description

The population genetic structure of *Centaurium muehlenbergii* in Canada has not been assayed. However, given the species' lack of specialized dispersal mechanisms and the fairly large distances (5 to 80 km) that separate the three *C. muehlenbergii* populations on southeastern Vancouver Island, genetic interchange among populations likely occurs infrequently, if at all. Given the apparent small effective sizes of most populations, loss of vigour due to local inbreeding effects could be a limiting factor for this species in Canada. Decreased fecundity and survival in relation to genetic diversity and population size were found in populations of *Gentiana pneumonanthe* (marsh gentian), a rare plant of European calcareous grasslands (Oostermeijer *et al*. 1994). This example involves a species within the same family as *C. muehlenbergii.*

Designatable units

A single designatable unit is recognized for *Centaurium muehlenbergii* in Canada because there are only three extant sites and these occur within a single ecozone.

DISTRIBUTION

Global range

Centaurium muehlenbergii occurs from southwest B.C. south to Washington, Oregon, Idaho, Nevada and California (Hitchcock *et al*. 1959, Hitchcock and Cronquist 1973, Douglas *et al*. 1999, NatureServe 2005) (Fig. 2). In Washington, *C. muehlenbergii* was known historically from Kittitas to Spokane Cos. and west through the Columbia River Gorge (Hitchcock and Cronquist 1973); it is still reported to be extirpated from that state (NatureServe 2005) in spite of a 1992 collection of this species from San Juan Island.

Centaurium muehlenbergii has also been reported from Texas, Louisiana, and Mississippi (USDA-NRCS 2005) but these specimens are likely misidentified *C. tenuiflorum* (J. Pringle, pers. comm. 2001).

Canadian range

In Canada, *Centaurium muehlenbergii* is known from two isolated sites on southeastern Vancouver Island (one in Oak Bay near Victoria, the other near Nanaimo) and a third from a single Gulf Island, E. Chatham Island, near Victoria (Fig. 3 and Table 1).

The Gulf Islands population was first recorded in 1933, the Oak Bay population in 1961 (HERB Database 2005). Until recently, these were the only two confirmed *Centaurium muehlenbergii* sites in Canada. However, in 2003, a third, small population was located near Nanaimo, effectively extending the known range of the species northward by approximately 80 km (Table 1).

A single unconfirmed, historical record, dating from 1911, exists from Stanley Park in Vancouver (Douglas *et al*. 2002), but this report was not based on a voucher collection. The species has not been reported again from this location suggesting that this record may be erroneous (M. Fairbarns, pers comm. 2003).

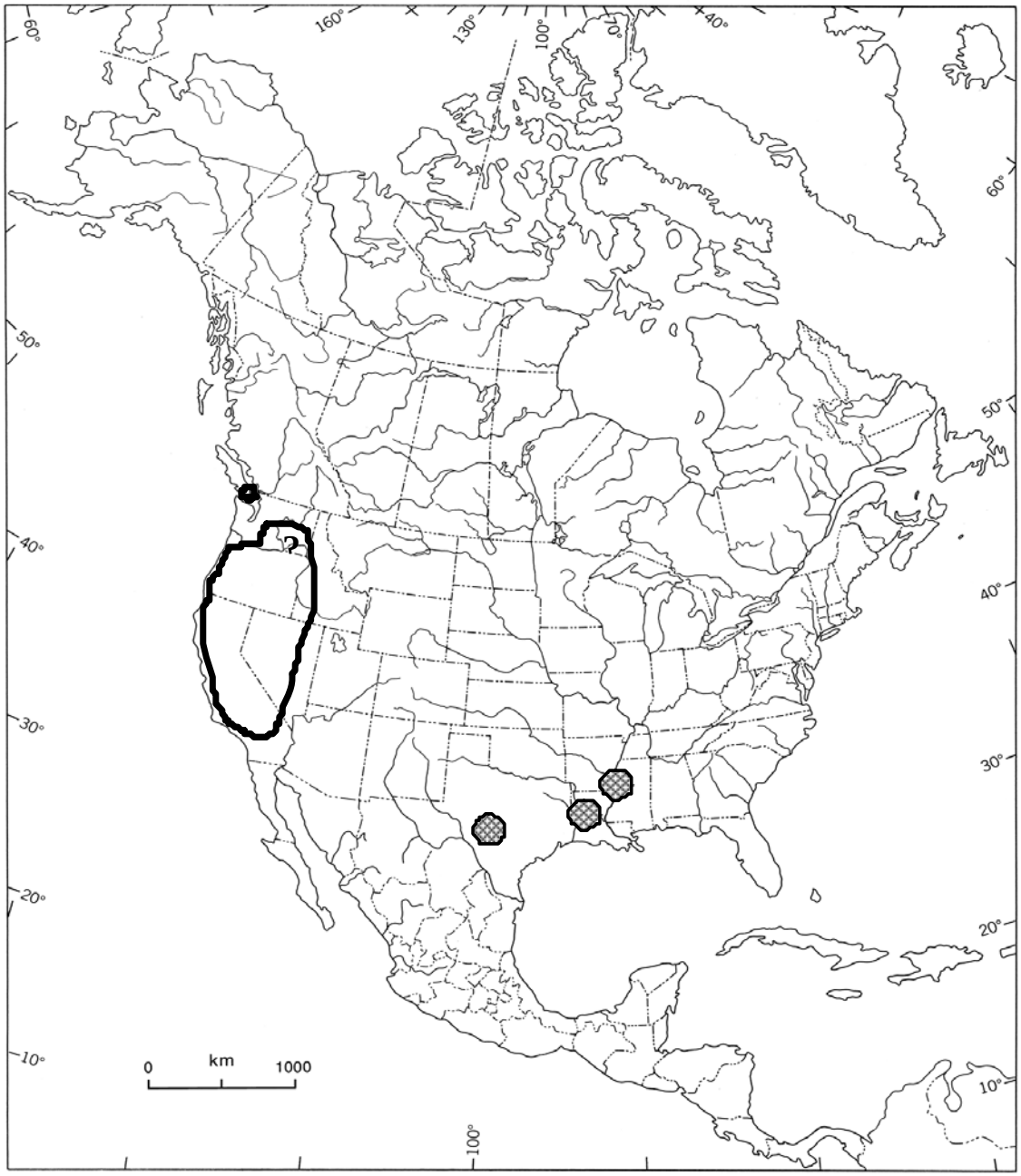


Figure 2. Approximate global range of *Centaurium muehlenbergii* (possibly extirpated in Washington State). Hatched circles are reported occurrences that are presumed to be incorrectly identified.

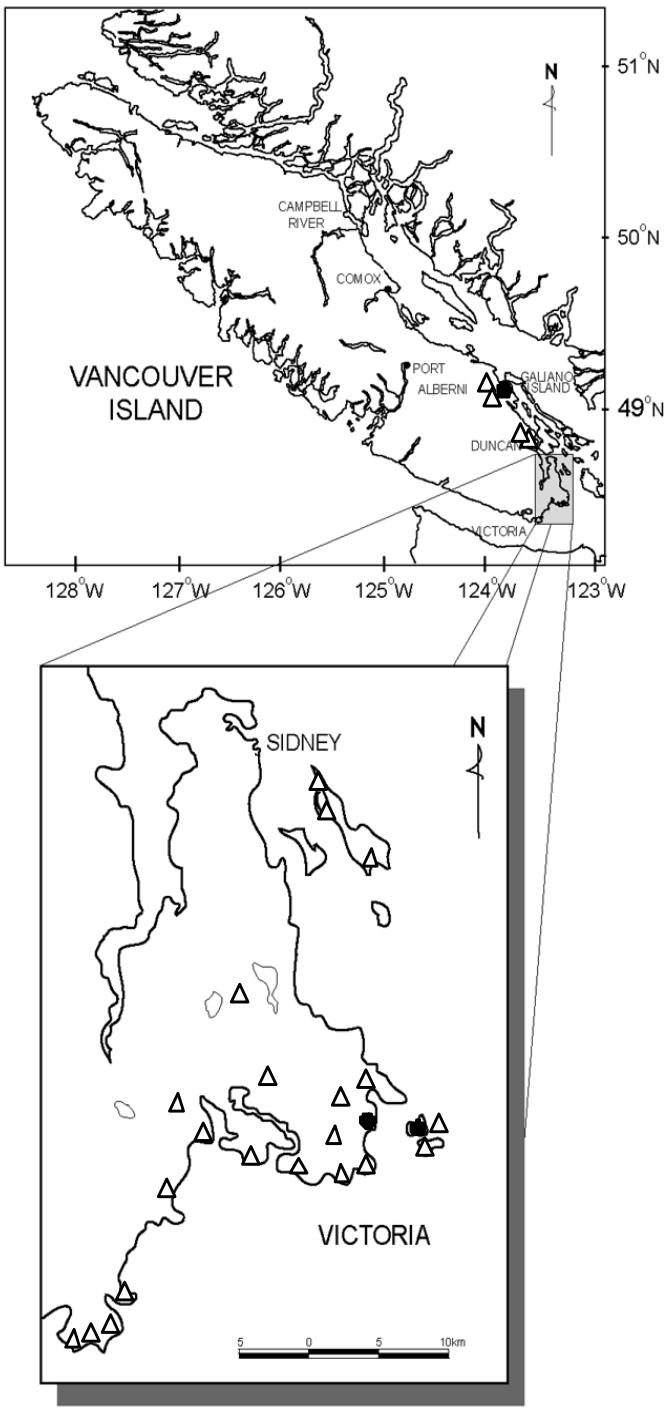


Figure 3. Range of *Centaurium muehlenbergii* in Canada. Solid circles: extant populations. Open triangles: survey locations where *C. muehlenbergii* was not found.

Table 1. General location, first and last observation dates, land tenure, and existing habitat protection (legal or "effective") for *Centaurium muehlenbergii* sites in Canada.

Population	First obs. & source[1]	Last obs. & source[1]	Land tenure	Protection (legal/effective)
Oak Bay (Victoria)	1961 / MCM	2004 / MM	Municipal park	None/partial
Gulf Islands (E. Chatham Is.)	1933 / HT	2002 / MM	Indian Reserve	None
Nanaimo	2003 / AC	2003 / AC	Private	None

[1]AC: Adolf Ceska; MCM: M.C. Melburn; MM: Mike Miller; HT: H. Toms.

The current Extent of Occurrence (EO) of *Centaurium muehlenbergii* in Canada is approximately 160 km^2, and the total area actually occupied is approximately 110 m^2 (0.0001 km^2). Based on a 1x1 km grid, the Area of Occupancy (AO) is 3 km^2 or 12 km^2 if based on a 2x2 km grid. This represents $<<$ 1% of the species' global distribution. The recent report of the population at Nanaimo likely represents the discovery of a previously existing and overlooked population.

The nearest U.S. populations of *Centaurium muehlenbergii* are in the Columbia River Gorge, over 300 km to the south. A collection of this species was made, however, in 1992 in the San Juan Islands (see accession number WTU 325083, at the University of Washington Herbarium). NatureServe (2007), however, still lists the species as historic (SH).

HABITAT

Habitat requirements

In Canada, *Centaurium muehlenbergii* is known from the Coastal Douglas-Fir Biogeoclimatic Zone (Douglas *et al*. 1999). This zone is limited to a small section of southeastern Vancouver Island, several islands in the Gulf of Georgia, and a narrow strip on the adjacent mainland (Meidinger and Pojar 1991). It is strongly influenced by the rain shadow of the Vancouver Island and Olympic mountains and has a sub-Mediterranean climate characterized by warm dry summers and mild wet winters. The mean annual temperature in Victoria is 10°C, with mean daily temperatures ranging between 4°C in December and 15.6 °C in July. Summer drought is an important feature determining the character of the vegetation in this region. Of the 690 mm of average annual precipitation in Victoria, $<$5% falls during July and August. The annual moisture deficit exceeds 350 mm (McMinn *et al*. 1976, Fuchs 2001).

Within this zone, *Centaurium muehlenbergii* has been reported from three rather distinct habitat types. The Oak Bay population is in a seasonally flooded meadow (i.e., vernal pool) in a Garry oak (*Quercus garryana*) woodland, at an elevation of 10 m. Trees are absent due to the wetness of the habitat. The soil beneath the population has not been profiled but is likely a poorly drained Tolmie or Gleysol developed from

medium to fine textured marine materials overlying marine clay parent material (Day *et al*. 1959, H. Roemer, pers. comm. 2003). The associated herb layer consists of a mix of native and non-native species such as Scouler's popcorn flower (*Plagiobothrys scouleri*), Kellogg's rush (*Juncus kelloggii*), tall woolly-heads (*Psilocarphus elatior*), water-plantain buttercup (*Ranunculus alismifolius* var. *alismifolius*), winged water-starwort (*Callitriche longipedunculata*), camas (*Camassia quamash*), toad rush (*Juncus bufonius*), chaffweed (*Anagallis minima*), and heterocodon (*Heterocodon rariflorum*). Kellogg's rush, tall woolly-heads, and water-plantain buttercup have all been listed as endangered by COSEWIC. A number of alien, invasive grasses (e.g., *Agrostis stolonifera*, *Bromus hordeaceus, Cynosurus echinatus, Holcus lanatus*, and *Dactylis glomerata*) are also present.

The Gulf Islands population is on a small Gulf Island (E. Chatham Is.) opposite Victoria. Here *Centaurium muehlenbergii* grows on bare sandy ground at the edge of a saltgrass (*Distichlis spicata*) marsh, just above the high tide mark. Associated species include purple-leaved willowherb (*Epilobium ciliatum*), brass buttons (*Cotula coronopifolia*), hairy cat's-ear (*Hypochaeris radicata*), and Baltic rush (*Juncus balticus*).

The Nanaimo population occurs on a sloping, mossy, vernal seep at the edge of a Douglas-fir (*Pseudotsuga menziesii*) and arbutus (*Arbutus menziesii*) forest. The substrate is a shallow, poorly developed mineral soil overlying sandstone or conglomerate bedrock of the Nanaimo formation. An invasive shrub, Scotch broom (*Cytisus scoparius*), has invaded this site and may be in the process of overgrowing it.

Centaurium muehlenbergii is federally classified in the U.S. as a facultative wetland species (USDA-NRCS 2005). Across its U.S. range, described habitats include coastal bluffs, wet openings in woods, and moist places in sagebrush scrub (J. Pringle, pers. comm. 2001); damp places below 500 m in redwood forest, oak woodland and mixed evergreen forest (Munz and Keck 1959); wet prairies (Guard 1995); northern oak woodland, foothill woodland, valley grassland, and northern juniper woodland (Calflora 2000); and serpentine and annual grassland (Callizo *et al*. 1997).

In summary, *Centaurium muehlenbergii* displays a fairly broad ecological amplitude, occurring in a variety of community types on soils ranging from sand to poorly drained Chernozem (with a possible tolerance for both saline and serpentine). The species is somewhat shade intolerant and may depend on periodic fire to maintain open habitat and limit competition. In Canada, it appears to prefer moisture-receiving sites that become wetted during the winter and spring but that dry up during summer.

Habitat trends

Little specific information exists as to historical losses or gains in the range and number of *Centaurium muehlenbergii* habitat patches per se in this region.

However, since the arrival of European settlers on southern Vancouver Island, most of the original Garry oak savanna has been lost as a result of agricultural and urban development. Remaining areas have been heavily impacted by encroachment of woody

species due to fire suppression, and by invasions of exotic species. It is currently estimated that <5% (<1000 hectares) of the Garry oak ecosystem remains in near-natural condition, and most of this is severely fragmented (Fuchs 2001). Moreover, Prentice and Boyd (1988) examined historical changes to estuarine habitats on the east coast of Vancouver Island, and estimated that estuarine marshes had already declined by >32% by the turn of the century. Although this loss then slowed, they noted that adjacent forests and agricultural lands were being increasingly replaced by other urban land uses.

Southeastern Vancouver Island is currently experiencing one of the most rapid rates of urban expansion in North America. In 1966, the population of metropolitan Victoria numbered around 180,000; by 1996, it had grown to 318,000 and is projected to surpass 400,000 by 2026 (BC Ministry of Management Services 2003). Likewise, the population of Nanaimo is expected to nearly double in size between 2001 and 2026, from 127,016 residents to over 219,000 residents (B.C. Ministry of Management Services 2003). This growth, with its attendant infrastructure, threatens to result in continuing fragmentation and loss of ecosystems through clearing, draining, and conversion to commercial and residential development, industry and agriculture (Ward *et al*. 1998).

Habitats suitable for *Centaurium muehlenbergii* were probably never as abundant as Garry oak and associated ecosystems in general. These habitats have certainly experienced at least an equally sharp decline, since price and demand for residential and commercial development are greatest in coastal areas where *C. muehlenbergii* tends to occur. Specifically, the Oak Bay and Nanaimo populations occur in small green spaces within or immediately adjacent to large residential areas built on similar sites that were formerly capable of supporting *C. muehlenbergii*.

Similar trends have occurred south of the border, where *Centaurium muehlenbergii* is a native forb of the remaining wetland prairies of the Willamette Valley (Wilson 2001). These prairies are highly fragmented and considered among the rarest of Oregon's ecosystems. Their decline can be traced to invasion of both woody plant species and pest organisms, agricultural and urban encroachment, and changes in hydrology (Clark and Wilson 2001).

Habitat protection/ownership

There is no specific legislation for the protection of rare and endangered vascular plants in British Columbia, or for the protection of Garry oak and associated ecosystems. This species can be added to the list of species for protection under the B.C. *Wildlife Amendment Act* (2004). Less than 1% of the Coastal Douglas-Fir zone is currently protected (Eng 1992).

The Oak Bay population occurs in a large urban municipal park managed by the District of Oak Bay (Table 1). No plans for development at this site exist at this time and are considered unlikely in the future. Nevertheless, this site receives heavy recreational use and does not afford more than a minimal level of protection for species at risk. The Gulf Island population is situated on First Nations land. Future plans for this site are

unknown. The Nanaimo population occurs on private land that is slated to have the land title of a portion of the property with the *Centaurium muehlenbergii* population present transferred to the City Parks Department by the developer (J. Kirby, pers. comm., 2008). Outside of these areas, most of the potential *Centaurium muehlenbergii* habitat in Canada is held by private landholders, and land use planning falls under the jurisdiction of local governments (GOERT 2002). Other areas are managed by B.C. Parks, Capital Regional District Parks, various non-governmental organizations, and the Department of National Defence. The proportion of potential *C. muehlenbergii* habitat represented within these different jurisdictions is unknown.

BIOLOGY

There is little published information available on the biology of *Centaurium muehlenbergii*. The sections that follow present summary information gleaned from floras, published literature on other *Centaurium* species, personal communications with *Centaurium* specialists, and the authors' own (unpublished) field observations.

Life cycle and reproduction

Centaurium muehlenbergii is a small herb of open moist habitats that flowers in the early summer. The fruit is a slender, 2-valved capsule containing numerous small seeds. Although successful fruit set has been observed in recent field surveys on Vancouver Island, rates of seed production and seedling recruitment have not been documented. The pollination system of *C. muehlenbergii* is also unknown (J. Pringle, pers. comm. 2001), although autogamy (self-pollination) and out-crossing are both known to occur within the genus (Kugler 1977). It is likely that allopolyploidy has occurred in several clades of *Centaurium*, and the *C. muehlenbergii* complex shows evidence of diverse introgressive hybridization (G. Mansion, pers. comm.).

Most authors refer to *Centaurium muehlenbergii* as an annual. The PLANTS Database (USDA-NRCS 2005) lists it as an annual or biennial. Hickman (1993) suggest that it may persist as a biennial if damaged.

No information is available on mortality rates or on the factors affecting the survival of *Centaurium muehlenbergii* at different stages of its lifecycle. However, the closely related *C. erythraea* is known to possess a large soil seed bank (Davies and Waite 1998), and it is possible that *C. muehlenbergii* also relies to some extent on a dormant seed bank to act as a buffer during periods of unfavourable environmental conditions.

Herbivory

There have been no observations of direct herbivory on *Centaurium muehlenbergii*. However, the Oak Bay site has been grazed by livestock in the past and is now heavily grazed by rabbits and deer, while the Gulf Island site hosts a large breeding population of Canada geese. The impact of these different herbivores on *C. muehlenbergii* is unknown,

although it is possible that, in some instances, grazing benefits the species by suppressing competing vegetation (M. Fairbarns, pers. comm. 2003).

Physiology

Species in the genus *Centaurium* are found in a wide range of habitats. Most are calcicolous, some are acidiphilous (e.g., *C. scilloides*), and a few are restricted to gypseous soils. However, edaphic conditions appear to be of less importance overall to *Centaurium* germination and growth than the amount of available moisture and sunlight (G. Mansion, pers. comm. 2001).

Dispersal

Centaurium muehlenbergii does not appear to have any specialized seed dispersal mechanisms. Most germination likely occurs within a few centimetres of the parent plant. The recent discovery of *C. muehlenbergii* near Nanaimo likely represents the finding of an unreported and established population that had previously been missed due to the extremely small number of plants (7). There have been no known instances of dispersal to a new area, or even of local colonizations, in the several decades since the species was first identified on southern Vancouver Island.

Interspecific interactions

Interspecific interactions are largely unknown. McGee (1985) reported that the related *Centaurium erythraea* was dependent on mycorrhizal infection for growth and survival under low nutrient conditions.

Most *Centaurium* species do not compete well with other species and therefore are generally found in disturbed or open places (G. Mansion pers. comm. 2001). *C. muehlenbergii* also appears to be a poor competitor and may be susceptible to competition from invasive species, especially introduced grasses (M. Fairbarns, pers. comm. 2003).

Adaptability

Aside from the possible existence of a seed bank, and an apparent ability to tolerate seasonally fluctuating moisture levels, *Centaurium muehlenbergii* is not known to possess any particular specializations that would allow it to adapt readily to sudden change or to stochastic events such as fires, extended drought, or human exploitation. No information relating to successes in artificial propagation, seed germination, or horticultural use was found. The feasibility of using cultivated seeds from horticultural sources for transplanting is also unknown. A closely related species, *C. erythraea* (common centaury, feverwort) is widely grown as a medicinal herb and appears in numerous garden and nursery seed catalogues in Canada, the U.S., and Europe. Planting instructions for this plant generally recommend seeds be sown in situ, in “average” to sandy soils, in full sun to partial shade.

POPULATION SIZES AND TRENDS

Search effort

There are three extant localities of *Centaurium muehlenbergii* in Canada. Only one of these (Oak Bay) has been surveyed regularly in the past decade. The Gulf Island population occurs on First Nations land with restricted access, while the Nanaimo population was not discovered until 2003 (Table 1).

In June 2002, the lead author conducted a week-long survey of potential *Centaurium muehlenbergii* habitat on southeastern Vancouver Island. The surveys were undertaken as part of a series of projects designed to document the distribution of rare plants in open meadows on southeast Vancouver Island and the Gulf Islands. Over the past decade, > 500 person-days have been spent searching for rare species in suitable habitats, spanning 1000 ha of suitable habitat in > 80 sites (Fairbarns *et al*. 2003). Using aerial photographs and topographic maps, potential habitat areas were identified and accessed wherever possible. An area of approximately 200 hectares was searched, without yielding any new localities (Table 1). Some potential territory was under private ownership with limited access, and was not searched. The search sites included: all of Trial Island and portions of Chatham Island, Discovery Island, Rocky Point, Uplands Park, Government House, Harling Point, Griffon Island, Little Saanich Mt., Mill Hill, Fort Rodd Hill National Historic Site, Witty's Lagoon, Sidney Island, Somenos Garry Oak Protected Area, Mt. Tzuhalem Ecological Reserve, and Harewood Plains (Fig. 3).

It is possible that *Centaurium muehlenbergii* continues to be overlooked elsewhere on southern Vancouver Island and the Gulf Islands, especially in some of the under-collected tidal marshes found along the coast. Continued surveys for this species are therefore recommended.

Survey method. The survey method used to date for *Centaurium muehlenbergii* is the "directed search." In this approach, surveyors familiar with the taxon in question rely on a combination of expertise and intuition to target areas most likely to support suitable habitat. They then sample the area for species presence/absence by walking it repeatedly until they are satisfied the habitat has been sufficiently well searched. This is generally considered by rare plant specialists to be the most efficient and cost-effective method of surveying for rare plants, and is the most common approach taken to date by botanists in British Columbia. However, this approach does not lend itself to statistical evaluations, making it difficult to assign confidence levels to past search efforts.

Abundance

The Oak Bay population is the largest known population with an estimated 800 (500-1000) flowering individuals in 2002. This represents a rough estimate only, based on a one-time count in 10 randomly placed 1-m^2 quadrats. It does not take into account the somewhat staggered flowering phenology of the plants or the possible presence of a dormant seed bank, either of which may have resulted in an underestimate of population size.

The Gulf Islands site contained 30 flowering plants in 2003. The Nanaimo population is a very small patch, with only seven plants tallied in 2003 (A. Ceska, pers. comm. 2004).

Fluctuations and trends

Early collection notes for *Centaurium muehlenbergii* on Vancouver Island do not specify population sizes, thus long-term population trends are unknown. However, both the Oak Bay and Gulf Island populations have persisted in small areas for at least 40 and 70 years, respectively, suggesting that population dynamics at these locations have remained relatively stable. On the other hand, it is well known that annual plants commonly undergo major fluctuations in population size from year to year (Harper 1977). The same probably holds true for this species. Considering the amount of habitat lost to development over the past century, it is conceivable that there has been a historical decline in the populations in the region.

Rescue effect

The nearest extant populations of *Centaurium muehlenbergii* outside Canada occur in Oregon State (NatureServe 2005). The status of plants represented by the 1992 collection on San Juan Island is unknown since the species is still recognized as of historic occurrence in the state. The distance between the Canadian and U.S. populations is such that natural interchanges between them, genetic or otherwise, are highly unlikely. Environmental differences between regions may have resulted in the evolution of distinct ecotypyes ill-adapted for survival in other environments. Such ecological or genetic divergence could seriously limit the feasibility of relying on sources of propagules from elsewhere for purposes of reintroduction should the Canadian population become extirpated.

LIMITING FACTORS AND THREATS

Given our current limited understanding of *Centaurium muehlenbergii* habitat requirements and population dynamics, it is unclear what factors have contributed to the species' current restricted abundance and distribution in Canada. Its rarity may be the result of intrinsic factors such as low competitive ability, limited dispersal ability, high habitat specificity, or inherently low recruitment and survival; extrinsic factors such as geographic barriers or past climatic changes; recent land-use history (e.g., habitat conversion, grazing, fire suppression); or a combination of any or all of these.

None of the seven threat factors identified below has been shown empirically to be responsible for declines (either current or historical) in the abundance or range of *Centaurium muehlenbergii* within Canada. This may simply be because the species has not been monitored long enough in its native Canadian habitat for deleterious impacts stemming from such threats. However, in the absence of any direct evidence to the contrary, the threats are considered here to be clearly imminent but with the level of impact uncertain.

1. Invasive species encroachment

The impact of invasive species is second only to that of habitat loss as a cause of species declines throughout the world (D'Antonio and Vitousek 1992, Myers and Bazely 2003). On eastern Vancouver Island, Garry oak and associated ecosystems have been invaded by non-native plants to such a degree that exotic species now comprise 59-82% of the total herbaceous cover (Roemer 1995 in Fuchs 2001, Erickson 1996). Furthermore, the proportion of introduced species in Garry oak meadows increased from an estimated 25% of the total in 1972 to 40-76 % of the total in 1995 (Roemer 1995 in Fuchs 2001), suggesting that the rate of invasion is accelerating rather than slowing. Some of these species represent accidental introductions but a large number have been intentionally introduced into the area for livestock forage, erosion control, or ornamental purposes.

Several authors have identified the types of processes that may be modified by non-indigenous plant species. In general, it is thought that invasive plants have the ability to pre-empt safe sites (places where seeds can germinate) and otherwise suppress recruitment of native plants; alter vegetation stand structure; increase soil moisture deficits; alter soils and micro-climates through litter deposition; increase the probability, extent and severity of fires through increased fuel loading; alter soil nutrient levels and distribution; and compete directly with native species for space, water, light, and nutrients (Bergelson 1990, Facelli and Pickett 1991, D'Antonio and Vitousek 1992, Smith 1994, Gordon 1998, Brown and Rice 2000, MacDougall 2002, Myers and Bazely 2003). In cases where introduced species have higher evapotranspiration rates than those of the native flora, hydrologic regimes may be permanently altered and water tables lowered, thereby altering the distribution of native species (Gordon 1998).

Oak Bay

The Garry oak meadow that supports this population has been heavily invaded by alien plant species, most notably perennial grasses such as orchard grass (*Dactylis glomerata*), sweet vernalgrass (*Anthoxanthum odoratum*), kentucky bluegrass (*Poa pratensis*), velvet-grass (*Holcus lanatus*), English ryegrass (*Lolium perenne*), creeping bentgrass (*Agrostis stolonifera*), and hedgehog dogtail grass (*Cynosurus echinatus*). Each of these grasses competes aggressively for water and nutrients and can form dense litter layers that block light and suppress the regeneration of native plants. Litter accumulation from these species also creates conditions for high-intensity fires (Garry Oak Ecosystems Recovery Team 2002). Orchard grass, which forms particularly extensive root systems and requires high nitrogen inputs, may pose the greatest imminent threat to *C. muehlenbergii* persistence. Originally introduced to coastal B.C. as a meadow forage crop, this species is still grown for hay and used in grass-seed mix to stabilize clearings and road cuts.

European ash (*Fraxinus excelsior*) is an introduced, exotic tree dominant in a 0.5 hectare section of the park not far from the *C. muehlenbergii* site. If not controlled, this species will likely continue to spread into adjacent areas, competing with native

vegetation for moisture, soil nutrients, and light (Collier *et al.* 2004). Other invasive shrubs posing a potential threat to *C. muehlenbergii* at this site include English hawthorn (*Crataegus monogyna*), Scotch broom (*Cytisus scoparius*), Himalayan blackberry (*Rubus discolor*), leather-leaved daphne (*Daphne laureola*), and gorse (*Ulex europaeus*). Due to the wetness of the habitat, however, these species are not likely to establish in the microsites occupied by *C. muehlenbergii*, and thus do not represent an immediate threat.

Orchard grass, velvet-grass, sweet vernalgrass, hedgehog dogtail grass, Scotch broom, gorse, leather-leaved daphne, English hawthorn, and Himalayan blackberry have all been ranked among the top ten invasive plants on Vancouver Island in terms of the significance of their impact on Garry oak and associated ecosystems, their resistance to control or management, and the urgency associated with their control or management (Murray 2004).

Gulf Islands

Introduced species do not appear to pose such a serious threat at this site, although the alien weeds brass buttons (*Cotula coronopifolia*) and hairy cat's-ear (*Hypochaeris radicata*) have both become established here and may be competing with *Centaurium muehlenbergii* for essential resources.

Nanaimo

The highly invasive Scotch broom has established on the margins of the vernal seep at this site, posing an imminent threat to *Centaurium muehlenbergii* and its habitat. Introduced to the Pacific Northwest as a garden ornamental in 1850, Scotch broom has since become a dominant component of the plant community on eastern Vancouver Island. In many areas this leguminous shrub forms monospecific stands that have completely overtaken the native vegetation (Roemer 1972, Fuchs 2001). A nitrogen-fixer, Scotch broom has the potential to increase soil nitrogen levels, thereby changing the supply of this resource to the ecosystem (Parker and Haubensak 2004). It also generates large amounts of woody fuel that can support high intensity fires and in this way alter the natural disturbance regime.

2. Trampling

Oak Bay

The municipal park that supports the Oak Bay population is situated in a residential area within a few km of downtown Victoria. Due to its accessibility, this location receives high volumes of pedestrian, bicycle, and dog traffic throughout the year, but particularly in the spring and summer months when the life cycle of *Centaurium muehlenbergii* is in its most critical stages. Light to moderate use by people on foot likely does not harm this species, and the trampling may actually help to suppress weeds (M. Fairbarns, pers. comm. 2003). On the other hand, traffic from bicycles and people can result in the

creation of new trails, change the micro-topography of vernal pool bottoms, truncate swale connectivity, crush vernal pool vegetation, and facilitate the spread of invasive plants. Although bicycling is prohibited within the park, this rule is rarely enforced, and soil compaction and heavy traffic have eliminated vegetation cover in many areas (Collier *et al*. 2004). Mountain bikers have in the past constructed unauthorized bike jumps close to the *Centaurium muehlenbergii* site, posing an additional threat to this population.

Dogs in the park are required to be on leashes throughout the spring months (April-June), but this rule is also rarely enforced, and dogs are regularly permitted to run, dig, and chase balls in the wet meadow containing the single known colony of *Centaurium muehlenbergii*. A recent park use survey conducted during the spring months found that almost 50% of visitors to the main meadow were accompanied by dogs, whereas only 2% of the dogs were observed to be on leash at a given time (Collier *et al*. 2004). The diminutive *C. muehlenbergii* plants are easily trampled or ripped up by dogs running through the site, and may also be vulnerable to being buried or crushed by dog feces. Commercial dog-walking services have recently begun to make use of the park on a regular basis, further exacerbating these impacts. A recently completed draft stewardship plan for the park notes: “The frequent presence of commercial dog walking activity in the Park will be highly damaging to soil and vegetation under most conditions. Particularly because plant species at risk are concentrated in open meadows where dogs are brought for exercise there is an obvious conflict between the preservation of park values and the uncontrolled use of the Park by some dogs” (Collier *et al*. 2004).

Gulf Islands

The Gulf Island site is a relatively remote, uninhabited island where direct threats from recreational activities are likely not a major factor.

Nanaimo

This site is adjacent to a public walking and mountain biking trail and is also prone to trampling by people, bicycles and dogs, especially in late spring after the ground has begun to dry but is still not yet hard.

3. Development

Oak Bay

Early land survey maps of Victoria and Oak Bay (from around 1860) indicate the presence of extensive Garry oak meadows and seasonal wetlands in areas now dominated by urban and residential developments. Many of these low-lying, vernally wet areas may have provided suitable habitat for *Centaurium muehlenbergii* at one time. It is now estimated that <5% of this habitat type remains (T. Lea, pers. comm. 2003). The

park containing the single extant *C. muehlenbergii* population is bounded on three sides by single-family residences and suburban streets, and on the fourth side by a thoroughfare. However, the park itself is being managed by the municipality as a natural area (Collier 2003), with no further developments planned at this time.

Gulf Islands

Long-term plans for this site (a First Nations Reserve) are unknown. However, development does not appear imminent.

Nanaimo

The vacant property supporting the Nanaimo population is owned by a private forestry company and is up for sale at the time of completion of this report. This ecologically unique region has been identified as a top-ten priority for protection and securement under the Recovery Strategy for Garry Oak and Associated Ecosystems (GOERT 2002). In recognition of this, the City of Nanaimo is now taking steps to develop a conservation/stewardship plan for the area in an attempt to protect both the habitat and resident species at risk (R. Lawrance, pers. comm. 2005). The land on which the *Centaurium* population occurs had been designated an Environmental Development Permit Area (EDPA), and as such is subject to restrictions on land use to ensure the viability of the sensitive ecosystems and rare plant species found there. The City of Nanaimo instructed the developer to set aside 7 hectares for conservation, encompassing grassland and upland ecosystems as well as the *Centaurium* population. The lot in question is still owned by the developer, but the plan is to transfer title of this piece to City Parks (J. Kirby, pers. comm. 2008).

4. Off-road vehicles

Traffic from off-road vehicles, which compacts the soil, facilitates the spread of invasive species, alters hydrology, dislodges and crushes vegetation, and fragments the habitat, is frequently cited as posing a threat to species of vernal pools and other ephemeral wetlands (Clark *et al*. 1998, U.S. Fish and Wildlife Service 1998, Douglas and Illingworth 1998, Donovan 2004, Parks Canada Agency 2006).

Oak Bay

Over the years, the occasional passage of trucks and other motorized vehicles through this park has left deep, long-lasting ruts through many of the vernal pools and low-lying meadows, including areas occupied by *Centaurium muehlenbergii*. The park's close proximity to residential neighbourhoods dictates that the municipality maintain an aggressive fire-suppression policy, such that fire trucks and other maintenance vehicles (e.g., mowers) continue to access the park on a periodic basis. Recently, a fire department truck became stuck in the central meadow containing *C. muehlenbergii* while servicing fire hydrants during the wet winter season. A load of gravel was subsequently brought in to fill the hole left by the fire truck, as a result of which a

segment of the remaining *C. muehlenbergii* population was lost (A. Ceska, pers. comm. 2004). In the event a wild fire does break out in the park, fire trucks and other heavy vehicles would likely have to be brought into the central meadow to help contain it, with potentially disastrous consequences for the *C. muehlenbergii* population there.

Nanaimo

Although not authorized for such use, this property is accessed on a periodic basis by ATV (all-terrain vehicle) enthusiasts, 4x4s and (to a lesser extent) dirt bikes. Off-road traffic has carved deep ruts down to bedrock through the seepage area occupied by *Centaurium muehlenbergii*, fragmenting the habitat, altering the watercourse, and directly endangering the survival of plants through crushing. Recreational off-roading has also disturbed and compacted the soil in surrounding upland meadows, reducing the long-term likelihood of *C. muehlenbergii* establishing in new areas.

5. Hydrologic alterations

Populations of annual plants are often naturally subject to strong variations in density over time and space (Venable and Lawlor 1980). However, high population turnover does not appear to be a fundamental characteristic of *Centaurium muehlenbergii* ecology at the northern limit of its range in British Columbia. This may be due to the relatively predictable nature of its environment (i.e., regular winter flooding alternating with summer drought conditions at two locations, periodic tidal flooding at another). At the same time, the extreme conditions posed by this fluctuating environment may have served historically to limit competition from less stress-tolerant woody plants and mesophytic herbs, thus facilitating the local persistence of *C. muehlenbergii.* If so, any major changes to the current hydrological regime, either as a result of local habitat perturbations or larger scale events such as global warming, could have a significant negative impact on the viability of *C. muehlenbergii* populations in Canada.

Oak Bay

This park has had an extensive history of draining and ditching dating back over a century, with significant consequences for the vegetation communities in the area (Collier *et al*. 2004). Most of the early water diversions were carried out to improve pasture for grazing, but constructed drainage systems for roads and residential properties adjacent to the park have also had permanent impacts on the local hydrologic regime (Collier *et al*. 2004). A busy suburban thoroughfare bisects the park at one end, effectively splitting the park in two. In addition, fire suppression has facilitated encroachment of woody species (both native and non-native) that may in turn be affecting light availability as well as patterns of surface and subsurface water flow through the site. At the same time, some area residents have called for increased ditching to reduce the amount of standing water on walking trails (R. Collier, pers. comm. 2005). Ditching has also been discussed as a way to eliminate mosquito breeding habitat in response to increased public concern over West Nile virus.

Nanaimo

As noted above, tire ruts left by off-road vehicles have affected the drainage patterns at this site, possibly to the detriment of the *Centaurium muehlenbergii* population. A transmission corridor bisects the property immediately adjacent to the population, further affecting the flow of water through the area. Past clear-cutting of adjacent forestland, and associated road construction, have likely had a considerable impact on the local hydrologic regime and may also have reduced the quality of *Centaurium muehlenbergii* habitat.

6. Altered fire regimes

Prior to European settlement of Vancouver Island, natural and human-initiated fires played an important role in the maintenance of the region's dry Douglas-fir forests and Garry Oak savannas (Turner and Bell 1971, Roemer 1972, MacDougall *et al*. 2004). The suppression of fire within the past century may have contributed to the demise of *Centaurium muehlenbergii* populations. Two of the three sites in which this species has been recorded (Oak Bay and Nanaimo) were probably maintained in the past by periodic burning. Fires would have suppressed much of the competing vegetation, resulting in open microsites where *C. muehlenbergii* might have become established. Fires may have also played an important role in the development and fertility of soils, by ensuring the steady release of organic nutrients into the upper soil horizon.

At the Oak Bay site, aggressive fire suppression management has led to a substantial reduction in the amount of *Centaurium muehlenbergii* habitat available locally, due to widespread encroachment of Douglas-fir (*Pseudotsuga menziesii*) and a dramatic increase over historical times in the cover of invasive native shrubs such as snowberry (*Symphoricarpos albus*), Nootka rose (*Rosa nutkana*), and Indian plum (*Oemleria cerasiformis*) (Collier *et al*. 2004). In open wooded areas where *C. muehlenbergii* may have once survived, snowberry and various species of exotic shrubs noted above now dominate the understory. The density of these species severely limits light penetration and thus growth of the herbaceous layer. Furthermore, the incursion of shrubs and trees into adjacent open habitats may have begun to affect local hydrologic and light regimes through alteration of drainage patterns, increased competition for water, increased shading, and thatch buildup. If unchecked, this process could result in feedback loops that accelerate the overall rate of secondary succession.

7. Canada geese

Canada geese (*Branta canadensis*) have been undergoing exponential population growth on southeastern Vancouver Island and adjacent islands since the 1960s, a growth spurred partly by intentional introductions (McGrenere 1990, Campbell *et al.* 1990, Carsen 2000). These birds are active grazers on vegetation, and in the process often churn up large areas of soil with their beaks. They have become abundant on the small Gulf Island occupied by *Centaurium muehlenbergii*. Here the steady grazing

activity, along with associated contamination from guano deposits, may be having negative impacts on *C. muehlenbergii* growth and survival. However, this has not been investigated or confirmed.

SPECIAL SIGNIFICANCE OF THE SPECIES

Centaurium muehlenbergii, because of its disjunct distribution in northwestern North America, may represent a relict from the Hypsithermal Interval of warm, dry climate 4,000-6,000 years b.p. No special ecological role has been identified for this species nor has it attracted significant research or public interest.

Most *Centaurium* species contain phytochemicals, primarily xanthones and secoiridoids (Khafagy and Mnajed 1970). Xanthones are yellow dyes that are pharmacologically active. Secoiridoids are responsible for the bitter taste of many gentians and are used for their digestive properties (G. Mansion, pers. comm.). The closely related *C. erythraea*, which contains both xanthones and secoiridoids, has a long history of use as a herbal remedy. A translation of a mediaeval Latin poem of the tenth century mentions this species as being powerful against ‘wykked sperytis.' It is also mentioned in a translation of a Slavic medical text from the fifteenth century (Grieve 1992). More recently, *C. erythraea* has been shown to have anti-inflammatory, antipyretic, antioxidant, antimutagenic and diuretic effects (Berkan *et al.* 1991, Schimmer and Mauthener 1996) and has been used as part of a herbal preparation to treat hyperglycemia (Petlevski *et al*. 2001). Other *Centaurium* species such as *C. linarifolium* are also known to have medicinal properties (Mandal *et al*. 1992). *Centaurium* species are used in the Pacific Northwest by herbalists to prepare a bitter tonic used to treat poor appetite and digestive problems (Moore 1995). However, *C. muehlenbergii* is not known to have any traditional First Nations uses in B.C. (N. Turner, pers. comm. 2003).

Specimens of *Centaurium muhlenbergii* found in B.C. may be of special interest genetically, insofar as populations on the periphery of a range are often genetically distinct from the main population. Such populations may be vital to the future survival of species, particularly in the face of global climate change.

EXISTING PROTECTION OR OTHER STATUS DESIGNATIONS

Centaurium muehlenbergii is not considered to be at risk globally (global heritage status rank: G5? (likely secure); U.S. national heritage rank: N5?). In Oregon, Nevada, Idaho, and California *C. muehlenbergii* is listed as SNR (unranked). In Washington, where it is presumed extirpated, its state ranking is SH (NatureServe 2005).

In British Columbia, *Centaurium muehlenbergii* is Red-listed with a provincial rank of S1 (critically imperiled); its Canadian national heritage rank is N1 (HERB Database 2005, NatureServe 2005). The species is not currently protected by law in Canada. However, the species could be protected under the B.C. *Wildlife Amendment Act* (2004 by provincial cabinet if the species is listed as extirpated, endangered or threatened in BC on the basis of a detailed status assessment.

One of the Canadian populations occurs in a municipal park, thereby affording it some measure of protection over the short term. However, no specific management plans are in place to protect *Centaurium muehlenbergii* at this or any other site.

TECHNICAL SUMMARY

Centaurium muehlenbergii
Muhlenberg's centaury petite-centaurée de Muhlenberg
Range of Occurrence in Canada :SW British Columbia

Demographic Information

Generation time (average age of parents in the population)	<1 yrs
Population trend and dynamics	
Observed percentage of reduction in total number of mature individuals over the last 10 years.	Unknown
Projected percentage of reduction in total number of mature individuals over the next 10 years.	Unknown
Observed percentage reduction in total number of mature individuals over any 10-year period, over a time period including both the past and the future.	Unknown
Are the causes of the decline clearly reversible?	Unknown
Are the causes of the decline clearly understood? Several impacts are known or suspected as limitations	Yes
Are the causes of the decline clearly ceased?	No
Observed trend in number of populations Historical decline; recent unknown	Unknown
Are there extreme fluctuations in number of mature individuals? Unknown but likely being an annual	Unknown
Are there extreme fluctuations in number of populations?	No

Number of mature individuals in each population

Population	**N Mature Individuals**
Oak Bay: Gulf Islands Nanaimo	800 (500-1000) ~30 ~7
Grand Total	837 (500-1000)

Extent and Area Information

Estimated extent of occurrence (km²) *Estimate is based on recent survey data and data from B.C. Conservation Data Centre, and represents roughly the area of the triangle formed by Nanaimo, Oak Bay, and nearby Gulf Islands. Historical 1911 Vancouver locality is excluded from EO estimate*	160 km²
Observed trend in extent of occurrence	Unknown
Are there extreme fluctuations in extent of occurrence?	No
Estimated area of occupancy (km²) Actual area occupied, based on authors' observations at occupied sites and on personal communication with A. Ceska, is about 110 m square. The Area of Occupancy based on a 1x1 km grid is 3 km²; that based on a 2x2 km grid is 12 km²	<20 km²
Observed trend in area of occupancy	Stable
Are there extreme fluctuations in area of occupancy?	No
Is the total population severely fragmented?	Yes
Number of current locations	3
Trend in number of locations The most recent collection simply represents a discovery of a previously existing and overlooked population. The trend is unknown, but likely stable since two of the populations have been known for at least 40 years	Unknown

Are there extreme fluctuations in number of locations?	No
Observed trend in quality of habitat	Decline

Quantitative Analysis

Threats (actual or imminent, to populations or habitats)

1. Invasive species encroachment – Oak Bay, Nanaimo
2. Trampling by walkers, dogs, and bicycles; dog scat – Oak Bay, Nanaimo
3. Urbanization/residential development – limited threats from presence of adjacent residential properties at Oak Bay
4. Off-road vehicles – Oak Bay, Nanaimo (some population loss at Oak Bay)
5. Hydrologic alterations – perhaps mainly of historic impact on the populations
6. Fire suppression – ongoing concern
7. Grazing by Canada geese and contamination from guano deposits – potential threat but not yet substantiated

Rescue Effect (immigration from an outside source)

Status of outside population(s)? USA: apparently secure in OR, NEV, CA and ID; presumed extirpated in WA	
Is immigration known or possible?	No
Would immigrants be adapted to survive in Canada?	Unknown
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	No

Current Status

COSEWIC: Endangered 2008

Status and Reasons for Designation

Status:	**Alpha-numeric code**:
Endangered	B1ab(iii)+2ab(iii)

Reasons for Designation:

This small annual plant occurs in only three small areas of mainly wet habitat in southwestern British Columbia. Its total Canadian population consists of fewer than 1000 plants. These are highly disjunct from the main range of the species that extends from Oregon to California and Nevada. The species is at continued risk from such factors as the spread of invasive plants and human activities including trampling in areas used for recreational activities.

Applicability of Criteria

Criterion A: (Decline in Total Number of Mature Individuals): Not applicable. No decline data
Criterion B: (Small Distribution Range and Decline or Fluctuation): Meets Endangered B1ab(iii)+2ab(iii). Extent of occurrence and area of occupancy are below critical values; it is severly fragmented with 3 widely separated locations known, with continuing decline inferred in quality of habitat based on existing threats.
Criterion C: (Small and Declining Number of Mature Individuals): Not applicable. Although the actual number of mature individuals is <2500, and at least 95% of the total population occurs at one site, Endangered C2a(ii) could not be applied because a projected decline in total number of mature individuals could not be inferred with certainty since two of the populations have been known for over 40 years.
Criterion D: (Very Small Population or Restricted Distribution): Meets Threatened D1, D2. Mature individuals are <1000 and the Area of Occupancy is much <20 km^2 with ongoing threats.
Criterion E: (Quantitative Analysis): None available

ACKNOWLEDGEMENTS AND AUTHORITIES CONSULTED

The authors would like to thank Matt Fairbarns, Adolf and Oluna Ceska, and B.C. Conservation Data Centre staff for assisting with field surveys, and Ted Lea and Brenda Costanzo for administrative support and editorial advice. Funding for this project was provided by the Nature Conservancy of Canada, the B.C. Conservation Data Centre and the B.C. Ministry of Water, Land and Air Protection (now Ministry of Environment).

Authorities consulted

Ceska, A. July 2004. Plant Ecologist, Ceska Geobotanical Consulting, Victoria BC.
Collier, R. July 2004. Consultant, Victoria.
Eberhardt, E. SAR Conservation Biologist / Data Mngt., Parks Canada National Office.
Fairbarns, Matt. Plant Ecologist, Aruncus Consulting, Victoria BC.
Fraser, D. March 2005. Species Specialist, Species at Risk, BC Ministry of Water, Land and Air Protection. PO BOX 9338 Stn Prov Govt, Victoria BC. V8W9M1
Lawrance, R. March 2005. Environmental Planner, City of Nanaimo.
Mansion, G. December 2001. Laboratoire de Botanique Evolutive, Institut de Botanique, Emile Argand 11, 2007 Neuchatel, Switzerland.
Penny, J. February 2005. Botanist, Conservation Data Centre, British Columbia Ministry of Sustainable Resource Management, PO BOX 9358 Stn Prov Govt, Victoria BC. V8T 5K7
Pringle, J. Botanist, Royal Botanical Gardens, PO Box 399, Hamilton, ON L8N 3H8.
Roemer, H. Botanist, Mimulus Consulting, Victoria BC.
Turner, N. Ethnobotanist, School of Environmental Studies, University of Victoria, Victoria BC.

INFORMATION SOURCES

Berkan, T., L. Ustunes, F. Lermioglu and A. Ozer. 1991. Anti-inflammatory, analgesic, and antipyretic effects of an aqueous extract of *Erythraea centaurium*. Planta Medica 57:34-37.
Bergelson, J. 1990. Life after death: site pre-emption by the remains of *Poa annua*. Ecology 71: 2157-2165.
B.C. Ministry of Management Services, Statistics Population Section, Government of British Columbia. Website: http//www.bcstats.gov.bc.ca [Accessed: July 6, 2003].
Brown, C.S. and K.J. Rice. 2000. The mark of Zorro: effects of the exotic annual grass *Vulpia myuros* on California native perennial grasses. Restoration Ecology 8:10-17.
CalFlora: Information on California plants for education, research and conservation. [web application]. 2000. Berkeley, California: The CalFlora Database [a non-profit organization]. Web site: http://www.calflora.org/. [accessed 03/02/27)
Callizo, J., J. Ruygt and G. Muth. 1997. The Flora of Napa County, California. Website: http://www.puc.edu/Faculty/Gilbert_Muth/napa.htm [accessed 01/11].

Campbell, R.W., N.K. Dawa, I. McTaggart-Cowan, J.M. Cooper, G.W. Kaiser, and M. McNall. 1990. Birds of British Columbia. UBC Press, Vancouver.
Carsen, D. 2000. 1999 Christmas bird count. Victoria Naturalist 56: 13-19.
Ceska, A. 2004. Pers. comm. Verbal communication to M. Miller, July 2004. Botanist, Ceska Geobotanical Consulting, Victoria, B.C.
Ceska, A. 2003. Pers. comm. Verbal communication to M. Miller, March 2003. Botanist, Ceska Geobotanical Consulting, Victoria, B.C.
Clark, D.L. and M.V. Wilson. 2001. Fire, mowing, and removal of woody species in restoring a native prairie in the Willamette Valley of Oregon. Wetlands 21:135-144.
Collier, R., F. Spencer and J. Miskelly. 2004. Uplands Park Stewardship Plan. Unpublished report to Parks and Recreation Commission, Municipality of Oak Bay. 70 pp.
Collier, R. 2005. Pers. comm. Verbal communication to M. Miller, March 2005. Vegetation Ecologist, Victoria, B.C.
COSEWIC. 2005. Instructions for the preparation of COSEWIC status reports. Web site: http://www.cosewic.gc.ca/pdf/english/instructions_2005_e.pdf [Accessed: March 10 2005].
Cronquist, A., A.H. Holmgren, N.A. Holmgren, J.K. Reveal and P.K Hol. 1984. Intermountain Flora: Vascular Plants of the Intermountain West, U.S.A, Vol. 4. Hafner Pub. Co., New York.
D'Antonio, C.M and P.M. Vitousek. 1992. Biological invasions by exotic grasses, the grass/fire cycle, and global change. Annual Review of Ecology and Systematics 23:63-87.
Davies, A. and S. Waite. 1998. The persistence of calcareous grassland species in the soil seed bank under developing and established scrub. Plant Ecology 136:27-37.
Day, J.H., L. Farstad and D.G. Laird. 1959. Soil survey of southeast Vancouver Island and Gulf Islands, British Columbia, Canada Department of Agriculture, Victoria, B.C.
Donovan, M. 2004. COSEWIC status report on the bog bird's-foot trefoil *Lotus pinnatus* in Canada, in COSEWIC assessment and status report on the bog bird's-foot trefoil *Lotus pinnatus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa 1-33 pp.
Douglas, G.W. and J.M. Illingworth. 1998. Status of the water-plantain buttercup *Ranunculus alismifolius* var. *alismifolius* (Ranunculaceae) in Canada. Canadian Field-Naturalist 112: 280-283.
Douglas, G.W., D. Meidinger and J. Penny. 2002. Rare Vascular Plants of British Columbia. BC Ministry of Sustainable Resource Management and BC Ministry of Forests, Victoria, BC.
Douglas, G.W., D. Meidinger and J. Pojar. 1999. Illustrated Flora of British Columbia. Volume 3: Dicotyledons (Diapensiaceae through Onagraceae). Province of British Columbia. BC Ministry of Environment, Lands and Parks and BC Ministry of Forests. Victoria. 401 pp.
Eng, M. 1992. Protected areas on Vancouver Island: an analysis of gaps in representation for conservation purposes. Ministry of Forests, 1991/1992 Progress report. Victoria BC.

Erickson, W.R. 1996. Classification and interpretation of Garry oak (*Quercus garryana*) plant communities and ecosystems in southwestern British Columbia. M.Sc. Thesis, University of Victoria, Victoria, BC.
Facelli, J.M. and S.T.A. Pickett. 1991. Plant litter: it's dynamics and effects on plant community structure. Botanical Review 57:1-32.
Fairbarns, M. 2003. Pers. comm. Verbal communication to M. Miller, March 2003. Botanist, Aruncus Consulting, Victoria, B.C.
Fairbarns, M., B. Costanzo, and A. Ceska. 2003. COSEWIC status report on Dense Spike Primrose (*Epilobium densiflorum*). Designated endangered by COSEWIC, May 2005.
Fuchs, M.A. 2001. Towards a recovery strategy for Garry oak and associated ecosystems in Canada: ecological assessment and literature review. Technical Report GBEI/EC-00-030. Environment Canada, Canadian Wildlife Service, Pacific and Yukon Region.
Garry Oak Ecosystems Recovery Team. 2002. Recovery strategy for Garry oak and associated ecosystems and their associated species at risk in Canada: 2001-2006. Draft 20 February 2002.
GOERT. 2002. Recovery strategy for Garry Oak and associated ecosystems and their associated species at risk in Canada: 2001-2006. Draft. Prepared by the Garry Oak Ecosystems Recovery Team.
Gordon, D.R. 1998. Effects of invasive, non-indigenous plant species on ecosystem processes: lessons from Florida. Ecological Applications 8:975-989.
Grieve, M. 1992. A Modern Herbal: The Medicinal, Culinary, Cosmetic and Economic Properties, Cultivation and Folklore of Herbs, Grasses, Fungi, Shrubs and Trees With All Their Modern Scientific Uses. Tiger Books International, London.
Guard, B.J. 1995. Wetland Plants of Oregon and Washington. Lone Pine Publishing, Vancouver, British Columbia. 239 pp.
Harper, J.L. 1977. Population biology of plants. Academic Press, London.
HERB Database. 2005. British Columbia Conservation Data Centre. B.C. Ministry of Sustainable Resource Management, Terrestrial Information Branch, Victoria, BC.
Hickman, J.C. [ed.]. 1993. The Jepson Manual - Higher Plants of California. University of California Press. Berkeley and Los Angeles, California.
Hitchcock, C. Leo, Arthur Cronquist, Marion Ownbey, J.W. Thompson. 1959. Vascular Plants of the Pacific Northwest. Part 4: Ericaceae through Campanulaceae. University of Washington Press, Seattle, WA. 510 pp.
Hitchcock, C.L. and A. Cronquist. 1973. Flora of the Pacific Northwest. University of Washington Press, Seattle.
Holmes, W.C., D.E. Wivagg. 1996. Identification and distribution *of Centaurium muehlenbergii* (Griseb.) Piper and C. pulchellum (Sw.) Druce (Gentianaceae) in Louisiana, Mississippi and Texas. Phytologia 80(1):23-29.
Kartesz, J.T. A synonymized checklist and atlas with biological attributes for the vascular flora of the United States, Canada, and Greenland. First edition. In: Kartesz, J.T. and C.A. Meacham. Synthesis of the North American Flora, Version 1.0 North Carolina Botanical garden, Chapel Hill, NC.
Khafagy, S.M. and H.K. Mnajed. 1970. Phytochemical investigation of *Centaurium pulchellum*. Acta Pharmaceutica Suecica 7(6): 667-672.

Kirby, J. 2008. Pers. comm. Landscape Ecologist Environment Canada, CWS, Pacific and Yukon Region, Delta B.C. communication to Elsa Gagnon, CWS, COSEWIC Secretariat.
Kugler, H. 1977. On the pollination of Mediterranean springtime flowers. Flora 166: 43-64. (English abstract only).
Lawrance, R. 2005. Pers. comm. Verbal communication to M. Miller, March 2005. Environmental Planner, City of Nanaimo.
Lea, T. 2003. Pers. comm. Verbal communication to M. Miller, March 2003. Vegetation Ecologist, B.C. Ministry of Environment, Victoria, B.C.
MacDougall, A. 2002. Fine-scale fire effects in *Quercus garryana* grassland *in* P.J Burton, (ed.) Garry Oak Ecosystem Restoration: Progress and Prognosis: Proceedings of the Third Annual Meeting of the B.C. Chapter of the Society for Ecological Restoration, April 27-28, 2002, University of Victoria. British Columbia Chapter of the Society for Ecological Restoration, Victoria, BC.
Mandal, S., P.C. Das and P.C. Joshi. 1992. Naturally occurring xanthones from terrestrial flora. Journal of the Indian Chemical Society 69: 611-636.
Mansion, G. 2001. Email correspondence to W. Miles. December 2001. Taxonomist, Laboratoire de Botanique Evolutive, Institute de Botanique, Neuchatel, Switzerland.
Macdougall, A.S., B.R. Beckwith and C.Y. Maslovat. 2004. Defining conservation strategies with historical perspectives: a case study from a degraded oak grassland ecosystem. Conservation Biology 18: 455-465.
McGee, P.A. 1985. Lack of spread of endomycorrhizas of *Centaurium* (Gentianaceae). The New Phytologist 101: 451-458.
McGrenere, M. 1990. Victoria Christmas bird count 1989. Victoria Naturalist 46:15-19.
McMinn, R.G., S. Eis, H.E. Hirvonen, E.T. Oswald, and J.P. Senyk. 1976. Native vegetation in British Columbia's Capital Region. Report BC-X-140. Canadian Forestry Service, Pacific Forest Research Centre, Victoria, BC.
Meidinger, D. and J. Pojar. 1991. Ecosystems of British Columbia. Special report series no. 6. Research Branch, BC Ministry of Forests, Victoria. 330 pp.
Moore, M. 1995. Medicinal Plants of the Pacific West. Red Crane Books, Santa Fe, New Mexico.
Munz, P.A. and D.D. Keck. 1959. A California Flora. University of California Press, Berkely, California. 1681 pp.
Murray, C. 2004. Decision support tool for managing invasive species in Garry oak and associated ecosystems in BC. Prepared by ESSA Technologies Ltd., Victoria BC, for the GOERT Invasive Species Steering Committee, Victoria.
Myers, J.H. and D. Bazely. 2003. Ecology and Control of Introduced Plants. Cambridge University Press, Cambridge.
NatureServe. 2005. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.3. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. [Accessed: March 21, 2005]
NatureServe. 2007. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.3. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. [Accessed: September 22, 2007]

Oostermeijer, J.G.B., M.W. van Eijck and J.C.M. den Nijs. 1994. Offspring fitness in relation to population size and genetic variation in the rare perennial plant species *Gentiana pneumonanthe* (Gentianaceae). Oecologia 97: 289-296.
Parker, I.M. and K. Haubensak. 2004. Soil changes accompanying invasion of the exotic shrub *Cytisus scoparius* in glacial outwash prairies of western Washington. Plant Ecology 175: 71-79.
Parks Canada Agency. 2006. Recovery Strategy for Multi-species at Risk in Vernal Pools and Other Ephemeral Wet Areas in Garry Oak and Associated Ecosystems in Canada. In *Species at Risk Act* Recovery Strategy Series. Ottawa: Parks Canada Agency. 73 pps.
Petlevski, R., M. Hadzija, M. Slijepcevic and D. Juretic. 2001. Effect of 'antidiabetis' herbal preparation on serum glucose and fructosamine in NOD mice. Journal of Ethnopharmacology 75: 181-184. (abstract only)
Prentice, A.C. and W.S. Boyd. 1988. Intertidal and adjacent upland habitat in estuaries located on the east coast of Vancouver Island - a pilot assessment of their historical changes. Technical Report Series No. 38, Canadian Wildlife Service, Pacific and Yukon Region. British Columbia.
Pringle, J. 2001. Email correspondence to W. Miles. December 2001. Botanist, Royal Botanical Gardens, PO Box 399, Hamilton, ON.
Roemer, H.L. 1972. Forest Vegetation and Environments on the Saanich Peninsula. Ph.D. thesis. Department of Biology, University of Victoria, British Columbia.
Roemer, H. 1995. Identity crisis: do we really know what we want to rehabilitate? Botanical Electronic News 105.
Roemer, H. 2003. Pers. comm. Verbal communication to M. Miller, March 2003. Botanist, Mimulus Consulting, Victoria, B.C.
Schimmer, O. and H. Mauthener. 1996. Polymethoxylated xanthones from the herb of *Centarium erythraea* with strong antimutagenic properties in *Salmonella typhimurium*. Planta Medica 62: 561-564.
Smith, J.M.B. 1994. The changing ecological impact of broom *(Cytisus scoparius)* at Barrington Tops, New South Wales. Plant Protection Quarterly 9: 6-11.
Turner, B.L. 1993. The Texas species of *Centaurium* (Gentianaceae). Phytologia 75 (3): 259-275.
Turner, N. 2003. Pers. comm. Verbal communication to M. Miller, March 2003. Ethnobotanist, School of Environmental Studies, University of Victoria, Victoria, B.C.
Turner, N.C. and M.A.M. Bell. 1971. The ethnobotany of the Coast Salish Indians of Vancouver Island. Economic Botany 25:63-99.
USDA-NRCS. 2005. The PLANTS Database, Version 3.5 (http://plants.usda.gov). National Plant Data Center, Baton Rouge, LA 70874-4490 USA. [accessed March 21 2005]
U.S. Fish and Wildlife Service. 1998. Vernal Pools of Southern California Recovery Plan. U.S. Fish and Wildlife Service, Portland, Oregon. 113 + pp.
Venable, D.L., and L. Lawlor. 1980. Delayed germination and dispersal in desert annuals: escape in space and time. Oecologia 26:272-282.

Ward, P., G. Radcliffe, J. Kirkby, J. Illingworth, and C. Cadrin. 1998. Sensitive ecosystem inventory: East Vancouver Island and Gulf Islands, 1993-1997. Vol. I: Methodology, ecological descriptions and results. Canadian Wildlife Service Pacific and Yukon Region, Environmental Conservation Branch.

Wilson, M.V. 2001. Common native forbs of wetland prairies - research from Oregon State University. Website: http://www.onid.orst.edu/~wilsomar/WetNatForbs.htm [accessed 03/02/26].

BIOGRAPHICAL SUMMARY OF REPORT WRITERS

Michael Miller has a Ph.D. in Biology from University of Victoria (2004). His Ph.D. research focused on the population ecology of mariposa lilies in the south Okanagan. He has written numerous COSEWIC status reports, including the report for Lyall's mariposa lily that led to its designation in 2001 as a federally threatened species. He has participated on a number of surveys for rare and endangered plants in southern British Columbia on behalf of the B.C. Conservation Data Centre. He currently volunteers as a member of the Plants at Risk RIG (Recovery Implementation Group) for the Garry Oak Ecosystems Recovery Team (GOERT).

Wynne Miles, R.P. Bio. completed her B.Sc. in 1974. She has been active in vegetation and wildlife studies throughout the province of British Columbia, as well as Alberta and the Northwest Territories. She has carried out several rare plant surveys for the B.C. Conservation Data Centre. In 2001 she wrote the GOERT Stewardship Account for Muhlenberg's centaury, and in 2002 assisted with the COSEWIC Status Report for *Syntrichia laevipila* Brid.

COLLECTIONS EXAMINED

The following herbarium collections were consulted:

- Oregon State University (OSU)
- Royal British Columbia Museum (V)
- University of British Columbia (UBC)
- University of Victoria (UVIC).