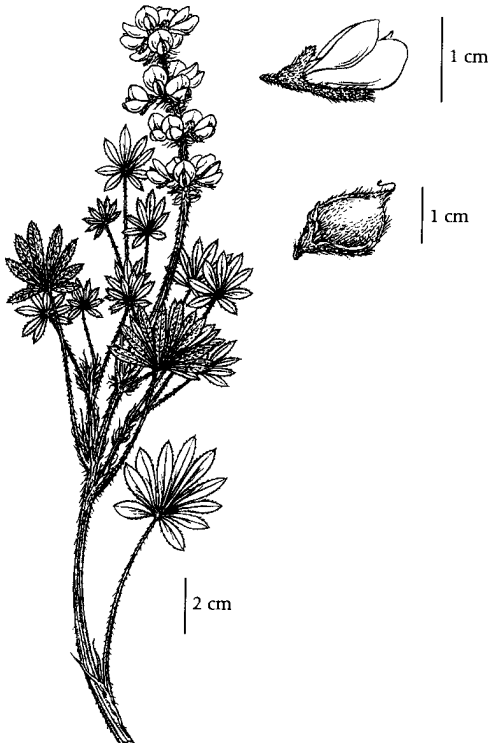
COSEWIC
Assessment and Status Report

on the

Dense-flowered Lupine
Lupinus densiflorus

in Canada



ENDANGERED
2005

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 2005. COSEWIC assessment and status report on the dense-flowered lupine *Lupinus densiflorus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 21 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

Production note:
COSEWIC acknowledges Shane Ford, Matt Fairbarns and Kathleen Wilkinson for writing the status report on the dense-flowered lupine, *Lupinus densiflorus.* This status report was produced with the initiative and funding of the British Columbia Conservation Data Centre. The COSEWIC status report review was overseen by Erich Haber, co-chair (vascular plants) of the 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.

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Également disponible en français sous le titre Évaluation et Rapport de situation du COSEPAC sur le lupin densiflore (*Lupinus densiflorus*) au Canada.

Cover illustration:
Dense-flowered lupine — Illustration of *Lupinus densiflorus* by Ronald With (Taylor, 1974).

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Catalogue No. CW69-14/440-2005E-PDF
ISBN 0-662-40626-5
HTML : CW69-14/440-2005E-HTML
0-662-40627-3


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COSEWIC
Assessment Summary

Assessment Summary – May 2005

Common name
Dense-flowered lupine

Scientific name
Lupinus densiflorus

Status
Endangered

Reason for designation
An annual with a highly restricted distribution known from three Canadian locations. The total population size is small and fluctuates considerably depending on climatic conditions. These populations are subject to continued risks from habitat loss and degradation due to activities such as urban development, trampling, mowing and competition with invasive exotic plants.

Occurrence
British Columbia

Status history
Designated Endangered in May 2005. Assessment based on a new status report.

COSEWIC
Executive Summary

Dense-flowered Lupine
Lupinus densiflorus

Species information

Lupinus densiflorus is an annual species, 20-30 cm tall. It has palmately compound leaves that occur at the base of the plants and alternately along the stem but tend to cluster near the top. The leaf stems and undersides, stems, flowers, and stalks are densely hairy and give the plant a distinctive, easily identifiable look. The white to pale yellowish-white flowers are densely clustered in whorls and give rise to egg-shaped pods that contain one or two seeds. Only a single variety of this species is recognized in Canada (*L. densiflorus* var. *densiflorus*).

Distribution

In Canada, *Lupinus densiflorus* occurs in localized populations in southern British Columbia. The populations tend to be small and intermittent on eroding shoreline slopes. At the species level, *L. densiflorus* ranges from British Columbia south to California where the taxonomy of the species is complicated by the presence of several varieties. The British Columbia populations, together with the plants in adjacent Washington state, are sometimes placed in a more narrowly-defined taxon (*L. densiflorus* var. *scopulorum*) that has a very restricted distribution, only extending from Victoria to adjacent islands in Puget Sound, Washington.

Habitat

In Canada, *Lupinus densiflorus* inhabits dry to moist grassy openings, clay cliffs and eroding grassy banks and benches above the seashore. It favours south or west facing exposures and level sites within the Coastal Douglas-fir biogeoclimatic zone.

Biology

Lupinus densiflorus is an annual herb that flowers from May until October. Most seeds germinate in the following autumn and winter while others remain dormant on the soil surface at least until spring. Seed set begins in June and July and may be prolific; seeds are thought to be gravity dispersed, though strong onshore winter winds may be an occasional dispersal agent.

There is little observed seed, flower or leaf herbivory, though large portions of the cotyledons may be consumed in some individuals and sub-populations. Most mortality probably occurs during the seedling stage and chance events during this period probably dictate year-to-year population fluctuations.

Population sizes and trend

Of the four sites at which *L. densiflorus* has been collected, the populations at three sites were confirmed in 2001 with population numbers ranging from 227 to 1045 individuals. The fourth population has been extirpated. There is not enough information to determine trends within populations, particularly the seed bank component of this annual species.

Limiting factors and threats

The primary threat to *Lupinus densiflorus* in Canada is the loss and degradation of shoreline habitat on public lands in the Victoria area due to property development and recreational use. Introduced shrubs and grasses also threaten the persistence of populations. All three populations are also at risk from oil spills since they grow near sea level along one of the most active oil shipping lanes in North America. Managing sites for this species is difficult because of the high public pressure for recreational opportunities and because there are few effective tools to control exotic shrubs and grasses.

Special significance of the species

The Canadian populations are a major component of a disjunct element that is often treated as a distinct variety endemic to Victoria and nearby islands of Washington State. Aboriginal use of this species has been reported in a major ethnobotany database.

Existing protection

Lupinus densiflorus is not legally protected by provincial or federal legislation or by site management plans for areas where it occurs.

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 agencies (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 members and the co-chairs of the species specialist and the Aboriginal Traditional Knowledge subcommittees. The Committee meets to consider status reports on candidate species.

DEFINITIONS (NOVEMBER 2004)

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 it 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 wildlife species for which there is inadequate information to make a direct, or indirect, assessment of its 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.

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

COSEWIC Status Report

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2005

TABLE OF CONTENTS

List of figures

List of tables

SPECIES INFORMATION

Name and classification

Scientific name:	*Lupinus densiflorus* Benth.
	Synonymy (from Pojar 1999; U.S.D.A. Natural Resources Conservation Service Plants Database):
	Lupinus densiflorus Benth. var. *scopulorum* C.P. Smith
	Lupinus microcarpus Sims var. *scopulorum* C.P. Smith
	Lupinus densiflorus Benth. var. *latilabris* C.P. Smith
	Lupinus densiflorus Benth. var. *stenopetalus* C.P. Smith
	Lupinus densiflorus Benth. var. *tracyi* C.P. Smith
	Lupinus microcarpus Sims ssp. *scopulorum* (C.P. Sm.) C.P. Smith
	Lupinus microcarpus Sims var. *densiflorus* (Benth.) Jepson
Common name:	Dense-flowered lupine or whitewhorl lupine
Family:	Fabaceae (Pea Family)
Major plant group:	Dicot flowering plant

Hitchcock *et al*. (1961), treating lupines in the Pacific Northwest, observed that "taxonomically, the genus is probably in a more chaotic state than any other to be found in our area". They noted that the species are extremely plastic and that many species interbreed freely. Barneby (1989) mentions the morphological uniformity of flowers and pods, which complicates classification. There is no evidence of *Lupinus densiflorus* breeding with other species in the Pacific Northwest.

Lupinus densiflorus, a member of the informal group *Microcarpi*, has a complicated history. Bentham described the combination but many taxonomists have included it within *L. microcarpus*, an earlier combination described from material grown in England from seed likely collected in Chile. Dunn and Gillett (1966) concluded that the two species — *L. densiflorus* and *L. microcarpus* — are distinct based on a number of morphological attributes. Riggins (1988) disagreed on the basis of a multivariate analysis of morphological characters and placed all members of the *Microcarpi* within one *L. microcarpus*.

Smith (1917, 1918a,b, 1919) described five species and 35 new or newly combined varieties within the *Microcarpi*, but subsequent authors have been reluctant to recognize all of Smith's taxa. Recent authors have referred to the element occurring in the Victoria area as *L. densiflorus* var. *densiflorus* (Pojar 1999), *L. densiflorus* var. *scopulorum* (Douglas et al. 1990), *L. microcarpus* var. *scopulorum* (Hitchcock *et al*.1961) and *L. microcarpus* var. *microcarpus* (Riggins and Sholars 1993).

Pojar (1999) recognized B.C. material as *L. densiflorus* var. *densiflorus* and his taxonomy has been adopted in this report. Apart from the three populations of *Lupinus densiflorus* var. *densiflorus* treated in this report there are no other Canadian occurrences of *Lupinus densiflorus* or *L. microcarpus*. The Canadian element of this species is referred to simply as *Lupinus densiflorus* in this report.

Morphological description

Lupinus densiflorus is an annual taprooted species that is usually branched and grows to 20-30 cm in height (Figure 1). The stems are usually fistulose (hollow and cylindrical) at the base, and sparsely to copiously long, brownish-pilose (long soft straight hairs). The leaves are palmately compound and occur basally and alternate along the stem but tend to cluster near the top. There are 8-10 elliptic-oblanceolate leaflets, 1.5-3 cm long, that are glabrous above and spreading-pilose below. The petioles are also very hairy and several times longer than the leaf blades. The stalked terminal raceme can be shorter or longer than the leaves, and may be densely clustered or interrupted, with the white to pale yellowish-white flowers in whorls. The flower clusters often persist as dried membranes when the plant is in fruit. The banner is 12-14 mm long, oblong, reflexed, short hairy on the central groove, and the wings and keel are ciliate on the margins toward the base. The calyx is bilabiate, with the upper lip membranous, very short (2-4 mm long) and 2-lobed; and the lower lip greenish, much longer (10-11 mm) and 3-toothed. The fruit is an ovate to rhomboid, hirsute (pubescent with coarse stiff hair) pod that is 1.5-2 cm long with a persistent style. The seeds, generally two but occasionally one per pod, are brownish tan to olive-coloured and 4-6 mm long.

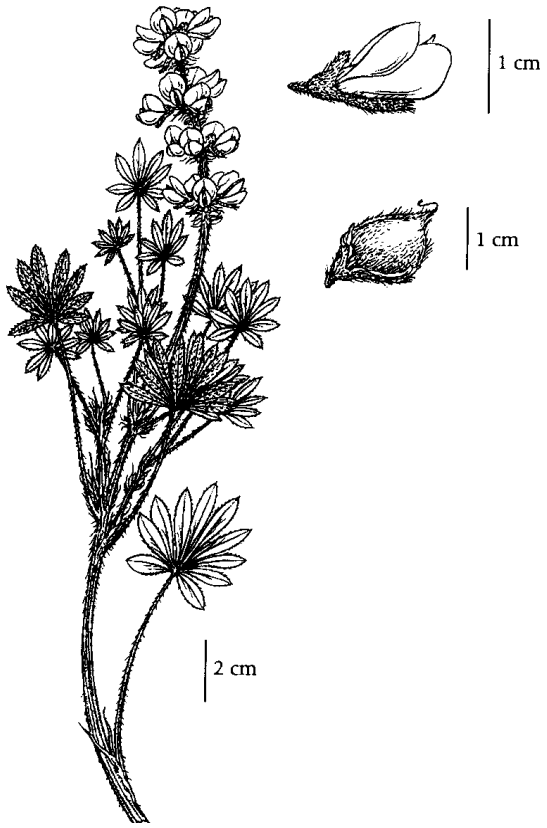

Figure 1. Illustration of *Lupinus densiflorus*: plant growth form (left); flower (top right; fruiting capsule (bottom right). Illustrated by Ronald With (Taylor, 1974).

Genetic description

No genetic work has been completed on this species though there are attempts underway to ascertain whether there is a genetic foundation to separate the southern main distribution of this species from the disjunct northern populations of British Columbia and Washington State.

DISTRIBUTION

Global range

Lupinus densiflorus (*sensu lato*) ranges from Vancouver Island and coastal Puget Sound, south on the east side of the Cascades to Baja California (Hitchcock and Cronquist 1973; Figure 2). The variety *scopulorum* (a more narrowly defined taxon that includes all Canadian material) is restricted to the area of Victoria, British Columbia, and adjacent islands of Washington State (Hitchcock *et al*. 1961, Pojar 1999).

Riggins (pers. comm.) has hypothesized that South American elements of the *Microcarpi* are deliberate or accidental introductions from California, made by early Spanish explorers. It is unlikely this was the case with populations in the Victoria area — Spanish explorers did not settle the area and the historical and extant populations do not correlate well with likely historical landing spots or ballast piles.

Dunn and Gillett (1966) speculated that the British Columbia populations of *L. densiflorus* "could represent an introduction of a seed from a single source". They based this hypothesis on three rather weak lines of evidence: (1) the uniformity of Canadian material; (2) obligate self-pollination of the plants; and (3) the disjunction between British Columbia plants and "the main population in the southern half of California". Subsequent authors (Taylor 1974, Clark 1976 but not Hitchcock *et al.* 1961 or Pojar 1999) appear to have adopted, as fact, the speculation that B.C. populations were introduced by Europeans.

The balance of evidence does not support Dunn and Gillett's hypothesis. Morphological and even genetic uniformity among annuals is not unusual, particularly in the genus Lupinus. Additionally, a single seed source certainly does not imply an anthropogenic introduction. Finally, the disjunct distribution of "var. *scopulorum*" (=var. *densiflorus* in Canada) is paralleled by several other "semi-desert" species[1] of the Pacific Northwest (Hitchcock et al. 1961), and it is unreasonable to assume they are all introductions. The sub-Mediterranean climate of Victoria and the Georgia basin is anomalous along the Pacific Northwest coast and may account for the pattern of disjunct distributions observed by Hitchcock et al. (1961).

[1]For example, *Allium amplectens, Crassula erecta (= C. connata), Clarkia purpurea* ssp. *quadrivulnera, Dryopteris arguta, Isoetes nuttallii, Juncus kelloggii, Minuartia pusilla, Microseris bigelovii, Montia howellii, Myrica californica, Ranunculus californicus, Trifolium depauperatum, Triphysaria versicolor, Vulpia pacifica,* and *Woodwardia fimbriata.*

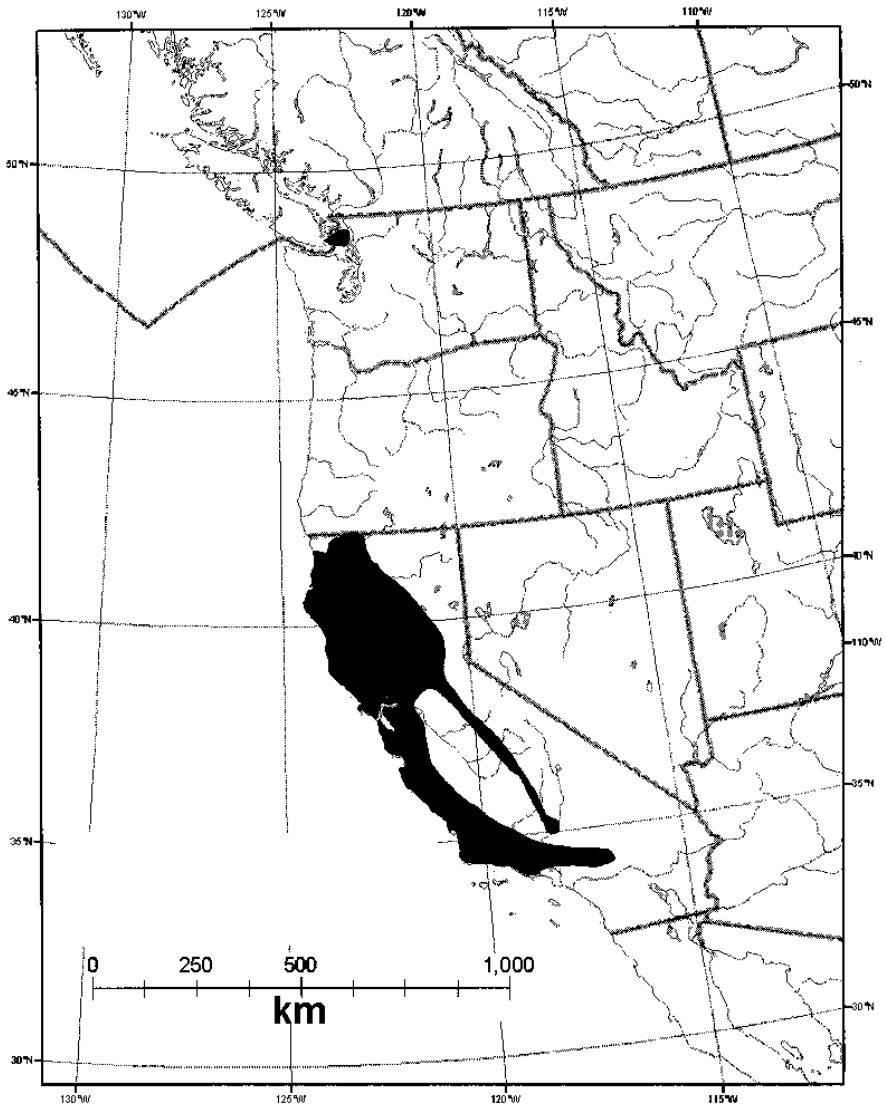

Figure 2. North American distribution of *Lupinus densiflorus* (distribution in Mexico not shown).

Three other lines of evidence support recognition of var. *densiflorus* as a native endemic to the area. Firstly, it is locally abundant and well distributed in the San Juan Islands of the Georgia basin despite the poor dispersal abilities of its seeds. Secondly, local material appears to be distinct (hence its recognition by some as var. *scopulorum*). Thirdly, it was collected in Victoria in 1887, early in the European settlement of Vancouver Island and at the very beginning of botanical studies in the area. In conclusion, there is little evidence to suggest it is an introduced taxon.

Canadian range

In Canada, *L. densiflorus* is restricted to three populations in the Victoria area of British Columbia (Pojar 1999; B.C. Conservation Data Centre database 2002; Figure 3). The extent of occurrence is a triangle demarcated by these three occurrences and measuring approximately 2 km^2. The area of occupancy measures about 0.12 ha (0.0012 km^2).

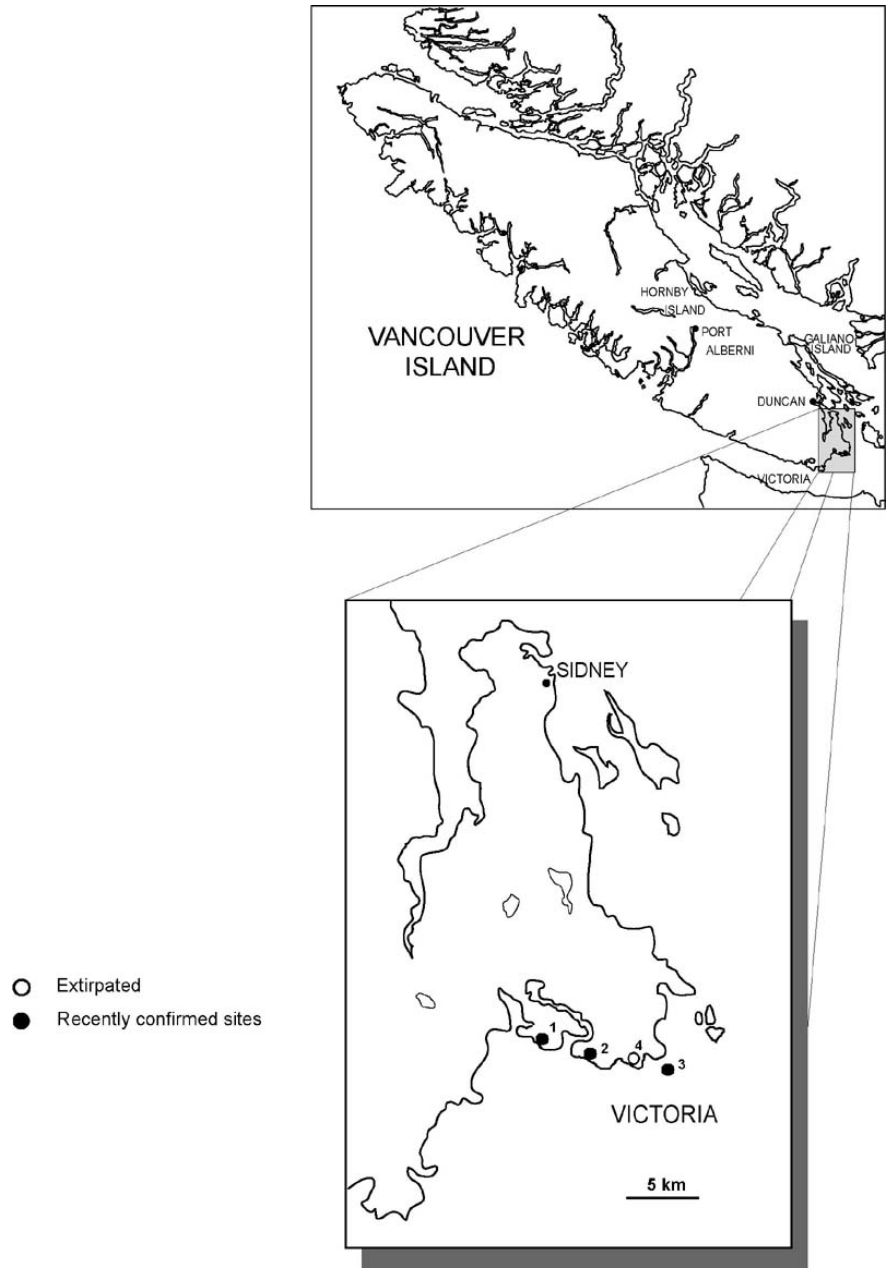

Figure 3. Canadian distribution of *Lupinus densiflorus*.

Lupinus densiflorus was formerly known from Clover Point, Victoria, where it was last collected on beach slopes and "grasslands" (RBCM accession numbers 101329 and 100762) in 1954. A 2001 survey of Clover Point failed to find any extant populations. This likely represents a historic decline in number of populations, number of mature individuals, and area of occupancy but no change in the extent of occurrence.

HABITAT

Habitat requirements

In Canada, *Lupinus densiflorus* is restricted to the lowland Coastal Douglas-fir biogeoclimatic zone. It occurs in dry to moist grassy openings, clay cliffs, and eroding grassy banks and benches above the seashore, usually with a south or west facing exposure. Shrubs on these eroding upper slopes include *Rosa nutkana* and *Symphoricarpos albus*. Associated native herbaceous perennials include *Allium cernuum*, *Armeria maritima*, *Brodiaea coronaria*, *Camassia quamash*, *Danthonia californica*, *Festuca rubra*, *Grindelia integrifolia*, *Lathyrus japonicus*, *Orobanche uniflora*, *Pteridium aquilinum* and *Lomatium nudicaule*. Many sites have a high cover of introduced grasses including *Dactylis glomerata*, *Lolium perenne*, *Bromus hordeaceus*, and *Bromus sterilis*. *Lupinus densiflorus* occurs in an elevational band up to 10 metres above the shoreline. A portion of population three grows in an atypical habitat — a level meadow with shallow soils that is dominated by introduced grasses and forbs. The other component of population three grows on moderate to steep, unstable slopes similar to the habitats favoured at populations one and two.

Habitat trends

Less than 1% of the Coastal Douglas-fir biogeoclimatic zone remains in a relatively undisturbed state (Pacific Marine Heritage Legacy 1996). Habitats suitable for *Lupinus densiflorus* have probably declined proportionally. Surveys of historical sites referenced in the Conservation Data Centre CDC database indicated that considerable habitat loss has occurred as a result of urban development.

Lupinus densiflorus is restricted to benches and banks above the ocean splash zone. Both the benches and banks have suffered from a gradual increase in excessive trampling damage over the past century. Fire suppression has likely favoured the development of dense shrub patches within populations one and two. Several introduced species of grasses and forbs have formed thick swards at all three locations. The dense shrub patches and thick swards appear to have substantially reduced habitat quality for *L. densiflorus* over the past century.

Habitat protection/ownership

The *Lupinus densiflorus* populations all occur in areas that are federally, provincially and municipally owned. No populations are known to occur on private

lands. None of the three levels of government have made provision for the conservation of *Lupinus densiflorus* in management plans. The species is not afforded protection under any general legislation or regulations in British Columbia.

BIOLOGY

General

Lupinus densiflorus is a winter annual; a large proportion of its seeds germinate during the fall and seedlings overwinter. No information is currently available on its biology and ecology in B.C.

Life cycle and reproduction

Information on pollination in Lupinus densiflorus is contradictory. Dunn and Gillett (1966) claimed that the Canadian population is maintained by obligate self-pollination and Riggins (pers. comm.) describes the species as cleistogamous. Direct observation of plants at Trial Island and Macaulay Point suggest a different breeding system. The petals are incompletely fused and bumblebees were observed foraging on the plants. The bees moved from plant to plant, only visiting fully-developed, fresh flowers. They appeared to probe the flowers carefully. This suggests that the Canadian populations of Lupinus densiflorus are chasmogamous and outcross regularly.

Surveys of British Columbia populations from September 2001 to February 2002 revealed that seed set was prolific, which is consistent with an annual species that has a seed bank as part of its lifecycle.

Germination

Some seeds germinate in the fall, as early as November in the Victoria area. During early February 2002, non-germinated seeds were observed on the soil surface at most plots. Germination may recommence in the spring, these seeds may enter the soil seed bank, or they may be lost through predation and other factors.

Germination requirements appeared to vary greatly among species of lupine. Seeds may remain dormant for long periods if the hard seed coat requires either decomposition or abrasion prior to germination. Neilson (1964) found that seeds of *L. densiflorus* remain viable for up to four years. Scarification may greatly improve germination — Neilson (1964) observed 100% germination of scarified seeds (n=10) in *Lupinus densiflorus* in his study of seeds from California populations. Some species of lupine germinate best in moist, loose soil when the temperature is relatively low, near freezing at night Dunn (1956). Under controlled conditions and adequate moisture, California collections of *L. densiflorus* germinated best at temperatures between 13 and 27°C (Neilson 1964).

Seedling ecology

Fall seedlings overwintered in the cotyledon stage or with a few emergent primary leaves. Neilson (1964) suggested that outgrowths of the cotyledons of *Lupinus densiflorus* form an effective enclosure over the leaf primordial, offering one of the best mechanisms in the genus for protecting seedlings. The cotyledons are persistent — collections of seedlings from Victoria bearing cotyledons were made as late as March and April (see RBCM accession numbers 142029 and 40414 respectively).

Observations were made from plots in populations one and two during the autumn of 2001 in order to track seedling survival during the winter. Seedlings were already established in the late autumn (as early as November) and overwintered with enlarged cotyledons and a few primary leaves. Large numbers of seedlings persisted throughout early and mid-winter, although seedling densities decreased in most plots as the winter progressed.

General observations in the winter of 2001/02 showed that seedlings germinate on a variety of substrates including gravel, rotting wood and crevices in driftwood. Most seedlings did not survive on such substrates and adults had not been found occupying similar substrates during the previous summer. Regardless of the substrate, salt-water flooding during high autumn tides caused the greatest mortality among seedlings.

Seedling establishment was most successful on clay soils saturated by winter rains. These soils are often subject to micro-slumping, which exposes bare mineral materials with cracks which taproots may penetrate easily. Seedlings may establish on level marine clays, as was observed at population three. *Lupinus densiflorus* seedlings were notably absent from lenses of sand and sandy silt at population two.

Survival

Though *Lupinus densiflorus* seedlings may germinate in a variety of microhabitats, seedling and juvenile mortality were common. Conversely, adult plants seemed to be more restricted, likely due to either edaphic requirements or competitive exclusion, but field observations during the summer of 2001 did not reveal any significant cases of adult mortality

Herbivory/predation

Some seed, flower and leaf herbivory was noted in most populations but was low and not considered a significant factor in population survival. At the seedling stage, some individuals may have large portions of the cotyledons consumed which could affect individual fitness. Inter-specific competition or chance events during this period probably dictate year-to-year population fluctuations.

Web references (e.g., http://www.crescentbloom.com/Plants/Specimen/LU/Lupinus%20densiflorus.htm) state

that the seeds, pods, and foliage contain the toxic alkaloid anagyrine, which may limit herbivory on this species.

Physiology

Little is known about the physiology of *Lupinus densiflorus*, although it may be symbiotic with nitrogen-fixing *Rhizobium* bacteria. Roots of young *Lupinus densiflorus* have abundant nodules that resemble those containing *Rhizobium,* and may also be a factor in survival and reproduction. The habitat of this species seems to offer low nutrient and low water availability during the summer and its competitive advantage may be enhanced through this symbiosis.

Lupinus densiflorus is physiologically adapted to winter conditions by germinating in the fall when water is available and maintaining itself in the cotyledon stage with a protective covering over the leaf primordia. Salt intolerance limits populations on the lower slopes that receive marine spray.

Dispersal/migration

If some or all flowers are cleistogamous, there is no opportunity for pollen dispersal. Otherwise, pollen dispersal in *Lupinus densiflorus* may be limited by the foraging behaviour of pollinators. Some species of bees are capable of fairly long-distance pollen transfer but little evidence of pollination was observed in the populations. This may enable genetic transfer within sub-populations but not among the three Canadian populations or with the Washington State populations. It is more likely that pollination occurs among flowers on the same inflorescence due to the density of the flowers and assumed pollinators' foraging behaviour.

Most seeds are probably passively gravity-dispersed. Onshore winter winds buffeting coastal bluffs in the Victoria area are very strong and may blow the seeds over short distances despite the lack of adaptations for wind-dispersal. This would be exceptionally important if populations are otherwise threatened by gradual depletion of up-slope plants. Explosive release of seeds from mature capsules has been reported in some lupines (e.g., Dunn 1956, Neilson 1964) but this was not observed in the field by the writers.

The localized distribution of British Columbia populations that are seemingly below site carrying capacity suggest that dispersal and establishment are rare and there would be limited rescue effect even among the 3 populations in the Victoria area.

Interspecific interactions

The potential interaction between *Lupinus densiflorus* and *Rhizobium* bacteria may have a significant effect on the survivorship of *Lupinus densiflorus* as a seedling or juvenile and may also potentially affect its ability to compete with other species. The ability of *Rhizobium* bacteria to fix nitrogen for its host legume plant in nitrogen-poor

environments is well documented. As the other major interaction is a negative one between *Lupinus densiflorus* and other native or non-native plants, the presence of nitrogen-fixing *Rhizobium* bacteria is likely to confer some competitive advantage.

Adaptability

Germination of *Lupinus densiflorus* has been treated previously and adaptations such as high seed set and germination, seasonal phenology, and seed banks represent common adaptations of annual species to unpredictable environments.

POPULATION SIZES AND TRENDS

Search effort

Search effort for this species included assembling locations for this species from herbaria (Royal British Columbia Museum, University of British Columbia and the University of Washington) and from the BC Conservation Data Centre and laying out transects between known sites. Prior to refining habitat requirements and a species search image, the surveying extended well beyond the known locations. Searching was initially conducted in the late summer and the distinctive foliage of *Lupinus densiflorus* made searching relatively easy. Additional searches were conducted in the fall and spring once it was determined that this species was a winter annual. The large, distinctive cotyledons of this species enhanced these searches and fall die-back of other competing species made searching easier. Summer search effort and measurement for the primary report writer was 16 hours and winter search effort was an additional 4 hours.

Although there is a high confidence that the primary report writers accurately delineated the current populations, there is little confidence in the numbers of individuals. Fine-scale studies of demographic patterns over a three-year period indicate that populations may fluctuate even more than has been documented in this report, although they still tend to be less than one order of magnitude (Fairbarns in prep.].

Abundance

The current areal extent of *Lupinus densiflorus* in Canada is 2 km^2 and the populations occur over 0.12 ha within that area. One of four known populations has been extirpated. Past observations of the other populations have included estimates of abundance but these appear to be too unreliable to use as a basis for tracking trends (see Fluctuations and trends section below). The populations, however, do experience sizeable fluctuations. Estimates from 2000 and 2001 suggest a total of between 1,800 and 2,100 individuals among the three main populations (Table 1).

Table 1. *Lupinus densiflorus* population survey data for 2000 & 2001.

Population	Last Observation	Population Extent (summary of colonies or sub-populations)	Number of Individuals
1	Ford and Fairbarns, 2001	20 x 10 m^2	1045
2	Ford and Fairbarns, 2001	20 x 12 m^2	227
3	Penny, Fairbarns and Ford, 2000	20 x 40 m^2	600 - 800
4	Ford, 2001	0 m^2	0

Fluctuations and trends

Lupinus densiflorus has not been sampled regularly or consistently over the three extant populations, which hampers any attempts at relaying accurate trend data. However, for annual species, trend data on numbers of individuals is of limited value as it is difficult to assess the seed bank constituents and also to standardize for variability in growing conditions year-to-year. Currently, the BC Conservation Data Centre has the following records, which are rough periodic counts of all or portions of the three extant populations:

Table 2. *Lupinus densiflorus* population trend data.

Population	Observer & date	Comment on Extent	Number of Individuals
1	M. Fairbarns, 2002	Entire population	200-300
2	J. Macoun, 1887	Extent of population sampled unknown	87
2	J. Penny, 1999	Portion of population	60-70
3	A. Ceska, 1993	Portion of population	200
3	M. Fairbarns, 2002	Entire population	800

Rescue effect

The United States populations of *Lupinus densiflorus* in Washington and California were not assessed for their health and viability. Inquiries to NatureServe Heritage program staff and web sites indicated that this species was not tracked. As mentioned in the previous section on name and classification, there is some question about the taxonomy of the southern and northern populations of *Lupinus densiflorus,* so it is likely that the Washington populations would provide the only viable seed source for species replacement in the present habitats of the Canadian populations. Having said that, the likelihood of natural transfer of seeds between BC and Washington State populations is very low due to the large expanse of hostile marine environments between the Victoria area of Vancouver Island, BC, and San Juan Island, Washington.

LIMITING FACTORS AND THREATS

Habitat loss presents a serious and urgent threat to *Lupinus densiflorus* in Canada. The specialized coastline habitats in Victoria and surrounding areas have been extensively developed for residential and commercial purposes and recreation facilities. Facility development almost certainly caused the loss of the Clover Point population.

Development of a sludge treatment plant at the site of population 1, a proposal under consideration by the Capital Regional District board of directors, would eliminate part or all of the largest Canadian populations of *Lupinus densiflorus* as well as the largest Canadian population of *Sanicula bipinnatifida* (designated threatened by COSEWIC). Two other sites are also under consideration. One of these alternative sites would eliminate part or all of a large population of *Limnanthes macounii* (designated threatened by COSEWIC) and a high-rank occurrence of an imperiled plant community.

Even if the sludge plant is not developed at the site of population 1, ongoing activities by the Department of National Defence (DND), the owner of the land, present a threat to the population. A portion of population 1 was destroyed in 2003 when DND widened and paved an existing track.

Habitat degradation compounds this threat. All three populations are threatened by the encroachment of exotic grasses and shrubs, most notably *Cytisus scoparius*, *Hedera helix*, *Ulex europaeus*, *Dactylis glomerata*, *Anthoxanthum odoratum*, *Lolium perenne*, *Bromus sterilis* and *B. hordeaceus*.

The warm dry sites that support *Lupinus densiflorus* were probably burned frequently by First Nations groups seeking to improve *Camassia* spp. production on the adjacent uplands. Fire has been almost completely suppressed on coastal sites for numerous decades, which has favoured ingrowth by introduced shrubs as well as native species including *Rosa nutkana, Symphoricarpos albus*, *Populus tremuloides* and *Pteridium aquilinum*. *L. densiflorus* was not found within dense patches of native or exotic shrubs or thick swards of introduced grasses.

Land management practices have also reduced site capability for *Lupinus densiflorus*. Landscaping, lawn fertilizing, de-thatching and mowing are all common practices on one or more populations. Lawn-mowing at Trial Island (to reduce the threat of fire) is deferred each year until after seed set has begun, in order to favor the perpetuation of *Lupinus densiflorus*. This informal agreement has undoubtedly had a positive effect, but the majority of plants are still mowed before seed set is complete.

Landform processes also influence lupine populations. The unstable slopes where lupines occur are susceptible to mass wasting and micro-slumping. The persistence of populations on these sites demonstrates that the plants can successfully survive a degree of slope instability. In fact, micro-slumping exposes numerous small fissures which expose mineral soil where seedling establishment is most successful. Currently,

mass wasting at sites of populations one and two greatly exceeds historic levels. Slope damage has increased with visitor traffic over the past century to a point where several sub-populations lie within a matrix of deeply worn footpaths and associated sheet erosion.

Summing up, it appears that less than 5% of the sites capable of supporting *Lupinus densiflorus* at the turn of the century currently provide suitable conditions.

Seed dispersal and rescue effects present a complex problem. At the broad scale, seed dispersal over distances greater than 10 m is probably extremely rare. The widely separated populations (including those on islands in nearby Washington state) have no potential for re-colonizing former sites. The potential for a rescue effect between sub-populations is also slight, as most are separated by well over 10 m of unsuitable habitat.

Within populations one and two, replenishment of up-slope elements is problematic. Seeds are gravity-dispersed. Stochastic events and increased human trampling might be expected to deplete up-slope elements. The former have not eliminated the second population first observed by Macoun in 1887, though we have no information from the Macoun collection as to where on the slope it was found. Thus, we have no way of telling whether or not the occurrence of *Lupinus densiflorus* first found in 1887 has been slowly migrating downslope to its current position barely above the high-tide line.

In populations one and two, human trampling has increased sharply over the years and many of the up-slope populations appear to be heavily impacted (particularly in the vicinity of trails and park benches). The loss of any up-slope elements cannot be balanced by recruitment into new down-slope habitats because the slopes all tail into the ocean. Severe winter winds may enable some 'rescue effect' within sub-populations by blowing seeds upslope, but this is unlikely to counterbalance up-slope human impacts in many populations.

Oil spills could also be potential risks, especially during autumn high tides.

SPECIAL SIGNIFICANCE OF THE SPECIES

The Canadian populations are a major component of a disjunct element that is often treated as a distinct variety endemic to Victoria and nearby islands of Washington State. Aboriginal use of this species has been reported in a major ethnobotany database (http://herb.umd.umich.edu/).

EXISTING PROTECTION OR OTHER STATUS DESIGNATIONS

Lupinus densiflorus (var. *densiflorus*) is not covered under the Convention on International Trade in Endangered Species (CITES), the Endangered Species Act

(USA) or the IUCN Red Data Book. NatureServe has designated a G5 T4 rank for *L. densiflorus* var. *densiflorus*. The G5 indicates that the species is classified as "common to very common; demonstrably secure and essentially ineradicable under present conditions". In California the species is common and abundant, often on disturbed soils (Riggins pers. comm.). The T4 ranking reveals that the variety is "apparently secure, with many occurrences". This variety rank should be considered with care given the perplexing status of infraspecific elements. In fact, if the plants of Victoria and adjacent islands of Washington state are treated a separate element as many authors propose, the true T-rank might be raised to T2.

The British Columbia Conservation Data Centre (2002) provincial ranking is S1, "critically imperiled, because of extreme rarity or because of some factor(s) making it especially vulnerable to extinction". *Lupinus densiflorus* is currently on the B.C. Conservation Data Centre RED LIST, which includes any indigenous species or subspecies (taxa) considered to be Extirpated, Endangered, or Threatened in British Columbia.

Lupinus densiflorus is not legally protected by provincial or federal legislation or by site management plans for areas where it occurs. The Macaulay Point and Trial Island populations will be eligible for protection by federal agencies (Department of National Defence and Canada Coast Guard, respectively, under the new Species at Risk Act (SARA) if the species is officially listed as threatened or endangered.

British Columbia does not protect endangered species through legislation. A portion of population two is afforded protection from development simply because it occurs within a municipal park. In fact, the entire population two is seriously threatened by recreation activities and some of the population is also threatened by facility development.

TECHNICAL SUMMARY

Lupinus densiflorus
Dense-flowered lupine lupin densiflore
Range of Occurrence in Canada: British Columbia

Extent and Area Information	
• *Extent of occurrence (EO)(km²)* [extent of terrestrial habitat encompassing the three extant locations]	2 km²
• *Specify trend in EO*	Stable
• *Are there extreme fluctuations in EO?*	No
• *Area of occupancy (AO) (km²)* [area occupied by the extant populations]	~ 0.0012 km² (0.12 ha)
• *Specify trend in AO*	Declining
• *Are there extreme fluctuations in AO?*	No
• *Number of known or inferred current locations*	3
• *Specify trend in #*	Unknown
• *Are there extreme fluctuations in number of locations?*	No
• *Specify trend in area, extent or quality of habitat*	Declining quality and extent
Population Information	
• *Generation time (average age of parents in the population)*	<1 year (annual)
• *Number of mature individuals*	1800-2000 (summed over 2 field seasons)
• *Total population trend:*	Unknown
• *% decline over the last/next 10 years or 3 generations.*	-
• *Are there extreme fluctuations in number of mature individuals?*	Uncertain but large fluctuations do occur
• *Is the total population severely fragmented?*	Yes
• *Specify trend in number of populations*	Stable (1 loss is likely historical)
• *Are there extreme fluctuations in number of populations?*	No
List populations with number of mature individuals in each: Pop. 1: 1,045 Pop. 2: 227 Pop. 3: 600-800	
Threats (actual or imminent threats to populations or habitats)	
- existing threats: trampling, urban development, lawn fertilization, landscape plantings, de-thatching, mowing; invasive plants - potential threats: population depletion due to downslope dispersal to unsuitable habitat; loss of population 1 due to sludge treatment facility development; oil spills	
Rescue Effect (immigration from an outside source)	
• *Status of outside population(s)?* **USA**:	Unknown
• *Is immigration known or possible?*	Unknown
• *Would immigrants be adapted to survive in Canada?*	Yes
• *Is there sufficient habitat for immigrants in Canada?*	Yes (likely below carrying capacity for habitat)
• *Is rescue from outside populations likely?*	No
Quantitative Analysis	Insufficient data
Current Status COSEWIC: Endangered (May 2005)	

Status and Reasons for Designation

Status: Endangered	**Alpha-numeric code**: B1ab (ii, iii,iv,v) + 2ab (ii, iii,iv,v); C1

Reasons for Designation:
An annual with a highly restricted distribution known from three Canadian locations. The total population size is small and fluctuates considerably depending on climatic conditions. These populations are subject to continued risks from habitat loss and degradation due to activities such as urban development, trampling, mowing and competition with invasive exotic plants.

Applicability of Criteria

Criterion A (Declining Total Population): Insufficient data

Criterion B (Small Distribution, and Decline or Fluctuation): Meets Endangered B1ab (ii,iii,iv,v) +2ab (ii,iii,iv,v) based on the very small extent of occurrence, area of occupancy, and the presence of only 3 populations. Declines are also inferred in area of occupancy, habitat quality, likely loss of a population if sludge treatment facility were to proceed at site 1, and decline in number of mature individuals due to human impacts, urban development and spread of alien plants. Large fluctuations in mature individuals occur but the data are not sufficiently comprehensive to determine if there is fluctuation greater than one order of magnitude. The fourth population likely was lost historically. Rescue from adjacent populations in the US is not possible.

Criterion C (Small Total Population Size and Decline): Meets Endangered C1 based on the presence of <2500 mature plants and the threat of the potential construction of a sludge treatment facility at site 1; this would result in the loss of about 50% of the total population of mature plants.

Criterion D (Very Small Population or Restricted Distribution): Meets threatened D2 based on the presence of only 3 populations and an area of occupancy <<20km^2 and a series of threats related to habitat degradation and loss through such activities as urban development, habitat use and management and expansion of alien plants.

Criterion E (Quantitative Analysis): Insufficient data

ACKNOWLEDGEMENTS AND AUTHORITIES CONTACTED

Acknowledgements

We would like to acknowledge the very valuable assistance of the British Columbia Conservation Data Centre, and in particular Brenda Costanzo, in the preparation of this report. We also gratefully acknowledge the assistance of Raji Basi in the field.

Funding for the preparation of this status report was provided by the Garry Oak Ecosystem Recovery Team and the BC Conservation Data Centre.

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Riggins, R. Professor Emeritus. California Poly.

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COLLECTIONS EXAMINED

The following collections were consulted:

- University of British Columbia herbarium
- Royal BC Museum herbarium
- University of Washington herbarium (e-mail contact with curator)