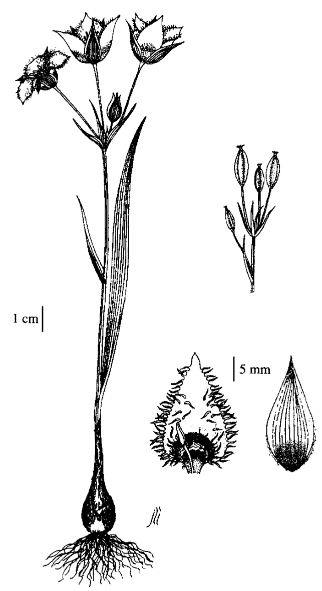
COSEWIC
Assessment and Status Report

on the

Lyall's Mariposa Lily
Calochortus lyallii

in Canada



THREATENED
2001

COSEWIC
COMMITTEE ON THE STATUS OF
ENDANGERED WILDLIFE
IN CANADA

COSEPAC
COMITÉ SUR LA SITUATION DES
ESPÈCES EN PÉRIL
AU CANADA

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Lyall's mariposa lily — Line drawing by Jane Lee Ling in Douglas *et al.* (1998a).

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COSEWIC
Assessment Summary

Assessment Summary – May 2001

Common name
Lyall's mariposa lily

Scientific name
Calochortus lyallii

Status
Threatened

Reason for designation
Very few highly localized populations occupying a very small area but generally present as large populations of many thousands of plants with threats from cattle grazing and loss of habitat from afforestation.

Occurrence
British Columbia

Status history
Designated Threatened in May 2001.

COSEWIC
Executive Summary

Lyall's Mariposa Lily
Calochortus lyallii

Description

Calochortus lyallii is a perennial, bulbiferous lily. Important diagnostic features include petals white to purplish, ciliate fringed, and with crescent shaped glands and erect capsules.

Distribution

Calochortus lyallii occurs along the eastern slope of the Cascade Mountains from extreme south central British Columbia to Yakima Co., Washington. Canadian populations are limited to a single height of land adjacent to the U.S. border, south of Richter Pass, between the Similkameen River and the Okanagan Valley.

Habitat

Calochortus lyallii occurs in open grass-forb meadows in Douglas-fir forest between 900 m and 1300 m elevation. Associated species are *Elymus spicatus, Festuca idahoensis*, *Zygadenus venenosus*, *Lupinus sericeus*, and *Ribes cereum*. Sites are dry and water-shedding.

Biology

Calochortus lyallii is a long-lived perennial, arising each year from a subterranean bulb and reproducing solely by seed. Flowers are insect pollinated and self-compatible. Seeds are shed in the summer and germinate close to the parent plant the following spring. Adult plants alternate between reproductive and vegetative states. Occasional dormancy is suspected but has not been documented. Herbage and fruit are browsed by insects and bulbs are browsed by small mammals.

Population Sizes and Trends

There are eleven known colonies (including six previously unrecorded sites) of *Calochortus lyallii* in Canada. The number of effective populations is likely fewer. The historical growth or decline in size of populations is unknown.

Limiting Factors

Silvicultural practices, including tree planting threaten *Calochortus lyallii*. In addition, trampling by livestock and exotic species are limiting factors. Herbivory by insects and small mammals could impact populations. Finally, pollinator availability and poor seed dispersal are instrinsic biological threats.

Existing Protection

Internationally, *Calochortus lyallii* is rare to uncommon. Provincial status is red-listed (critically imperiled because of extreme rarity) as designated by the British Columbia Ministry of Environment, Lands and Parks.

COSEWIC MANDATE

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

COSEWIC MEMBERSHIP

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

DEFINITIONS

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

* Formerly described as “Vulnerable” from 1990 to 1999, or “Rare” prior to 1990.
** Formerly described as “Not In Any Category”, or “No Designation Required.”
*** Formerly described as “Indeterminate” from 1994 to 1999 or “ISIBD” (insufficient scientific information on which to base a designation) prior to 1994.

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list.

Environment Canada / Environnement Canada
Canadian Wildlife Service / 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

Lyall's Mariposa Lily
Calochortus lyallii

in Canada

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2001

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SPECIES INFORMATION[1]

Name and classification

Scientific name:	*Calochortus lyallii* Baker[2]
Common name:	Lyall's mariposa lily; Lyall's star tulip
Family name:	Liliaceae; Lily Family
Major plant group:	Monocot flowering plant

Description

Calochortus lyallii is a perennial tulip-like herb with one to twelve white or purplish-tinged bell-shaped flowers and a single long, flat basal leaf. The smooth hairless stem, which bears an additional bract-like leaf below the inflorescence, measures ten to thirty cm and arises anew each year from a deep-seated, egg-shaped bulb. The flowers are borne on slender erect stalks (pedicels), have three petals, three sepals, and measure two to three cm across. The petals are broadly lance-shaped, with fringed margins and a bearded, crescent-shaped gland toward the base. The oval seed capsules are erect and strongly 3-angled (Figure 1).

The size of the basal leaf varies greatly and is dependent on the age/stage of the individual. The basal leaves of flowering plants are generally as long as the stem and one to two cm wide. Immature plants, which produce no stem and which are therefore visible above ground only by the solitary leaf, may be as small as four cm x 1.5 mm, or about the size of a flat plastic toothpick.

Calochortus lyallii is easily distinguished from the only other locally occurring member of the genus, *C. macrocarpus* (sage brush mariposa), by its fringed white petals (the much larger petals of *C. macrocarpus* are lavender and have no fringe) and flat basal leaf (the basal leaf of *C. macrocarpus* is strongly channeled, and in cross section, v-shaped). The two species are distinguished in fruit by their seed capsules, which in *C. macrocarpus* are long, narrow and wingless. The genus is aptly named: from the Greek, *kalo* = beautiful and *chortus* = grass.

For a more technical description, see Hitchcock et al. (1969) or Owenby (1940).

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[1] Most of the information appearing in this report was published previously by Miller and Douglas (1999).
[2] Nomenclature follows Douglas *et al*. (1994, 1998b, c; 1999a, b and 2000).

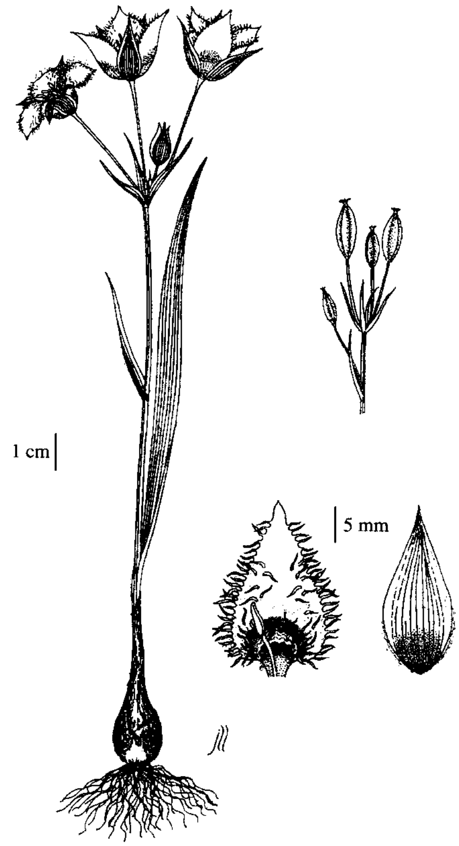

Figure 1. Illustration of *Calochortus lyallii.* Line drawing by Jane Lee Ling in Douglas *et al.* (1998a).

DISTRIBUTION

Global range

C. lyallii occurs along the eastern front of the Cascade Mountains, from south central British Columbia southward to northern Yakima County, Washington (Owenby 1940; Hitchcock et al, 1969, Douglas *et al.* 1998 a, b), with particularly high concentrations around Methow Valley, northcentral Washington.

Canadian range

In British Columbia, *C. lyallii* is limited to the height of land separating the Okanagan and Similkameen Valleys in extreme south central British Columbia, west of the town of Osoyoos and south of Richter Pass (Figure 2). All known sites occur within 5 km of one another and are within 5 km of the U.S. border.

Owenby (1940) refers to a single British Columbia collection (by Macoun in 1905) from “open hilltops near Similkameen River, 1050 m alt.” The exact location and status of this population are unknown.

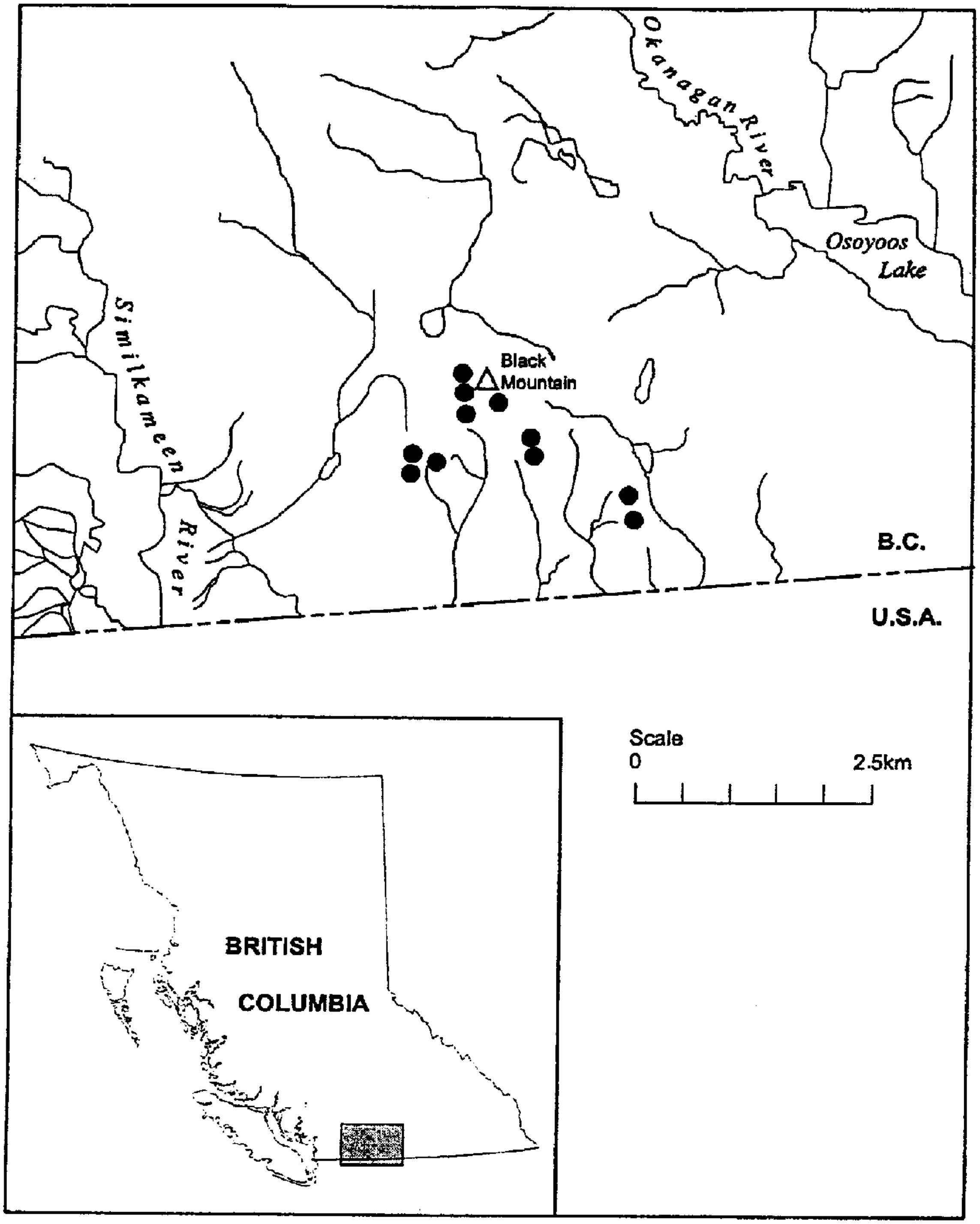

Figure 2. Distribution of *Calochortus lyallii* in British Columbia.

HABITAT

General Physiography

The British Columbia range of *C. lyallii* falls within the South Okanagan Basin Ecosection of the Southern Interior Ecoprovince (Demarchi, 1996). In terms of the biogeoclimatic ecosystem classification system employed by the province (Meidinger and Pojar, 1991), this area forms part of the IDFxh1, or Okanagan very dry hot Interior-douglas fir variant of the Interior Douglas-fir zone (Lloyd et al., 1990; Bryan, 1996). In this area, a continental climate is moderated by the rain shadow cast by the Coast-Cascade Mountains, resulting in warm, dry summers and cool winters (Meidinger and Pojar, 1991). The substrate is composed mainly of glaciated granodiorite, known as Kruger Synite, overlain by glacial till (Bryan, 1996). Soils at the study sites range from Eutric Brunisols to dark Chernozems (Bryan, 1996).

Community Structure and Composition

C. lyallii inhabits natural openings in Douglas-fir (*Pseudotsuga menziesii* var. *glauca*) forest, on all aspects, at elevations ranging from 900-1300 m. Mainly grass-forb meadows, these sites range from dry to mesic, occur on slopes of zero to 40%, and contain a diverse plant community dominated by two species of bunch grass, *Elymus spicatus* (bluebunch wheatgrass) and *Festuca idahoensis* (Idaho fescue). Other grasses commonly associated with *C. lyallii* are *Koeleria macrantha* (junegrass) and *Calamagrostis rubescens* (pinegrass). Common forbes include *Zygadenus venenosus* (death camas), *Fritillaria pudica* (yellow bell), *Balsamorhiza sagittata* (arrow-leaved balsamroot), *Lupinus sericeus* (silky lupin), and *Collinsia parviflora* (blue-eyed Mary) (Table 1). On dryer sites, *Lewisia rediviva* (bitterroot) and *Artemisia tridentata* (big sagebrush) comprise part of the association. Shrub cover is generally sparse, but includes *Spirea betulifolia* (birch-leaved spirea), *Ribes cereum* (squaw currant), and *Amelanchier alnifolia* (saskatoon) (Table 1). A few invading/residual Douglas-fir trees are also present at most of the sites.

Two species associated with *C. lyallii, Haplopappus carthamoides* ssp. *carthamoides* (Columbian goldenweed) and *Orobanche corymbosa* ssp. *mutabilis* (flat-topped broomrape), are very rare in British Columbia (Douglas et al., 1998a), and are being reported from the area here for the first time. Both species are named on the provincial Red List maintained by the British Columbia Conservation Data Centre.

Many of these plants are indicator species for moderately dry to dry, water-shedding sites with shallow, nitrogen-medium soils (or, in the case of *Elymus spicatus*, extremely dry, nitrogen-rich soil), their occurrence tending to decrease with increasing elevation and precipitation (Klinka et al., 1989). Similar meadow associations are fairly common in the high country south of Richter Pass, and probably represent subclimax communities maintained in an early successional stage by periodic fires. As it happens, a wildfire swept through the study area in the summer of 1994, incinerating most of the surrounding forest but leaving the herb community largely intact. Given that *C. lyallii* is relatively shade intolerant and does not grow under dense canopy, such disturbances may play an important role in maintaining sufficient open habitat for the species. In the absence of disturbance, normal forest succession in this community type is expected to occur within 100+ years (Ecosystems Working Group, 1995).

Table 1. Summary of localities, aspect and associated species of *Calochortus lyallii*

Locality	Slope/aspect	Associated vascular plant species
Black Mountain:		
East slope (#1)	0-35%/N45E-S45E	*Elymus spicatus* *Festuca idahoensis* *Astragalus miser* *Haplopappus carthamoides* *Orobanche corymbosa* *Lewisia rediviva* *Lomatium ambiguum* *Fritillaria pudica* *Collinsia parviflora* *Artemisia tridentata*
East slope (#2)	*15-25%/N45E	*Pseudotsuga menziesii* var. *glauca* *Calamagrostis rubescens* *Zygadenus venenosus* *Astragalus mise*
North slope (#1)	0-35%/N80W-N45E	*Elymus spicatus* *Festuca idahoensis* *Amelanchier alnifolia* *Spirea betulifolia* *Erigeron corymbosa* *Lupinus sericeus* *Balsamorhiza sagittata* *Koeleria micrantha* *Collinsia parviflora* *Calamagrositis rubescens*
North slope (#2)	0-30%/N80W-N80E	*Elymus spicatus* *Festuca idahoensis* *Calochortus macrocarpus* *Heuchera cylindrica* *Erigeron corymbosa* *Lupinus sericeus* *Balsamorhiza sagittata* *Koeleria micrantha* *Lomatium macrocarpum* *Calamagrositis rubescens* *Achillea millefolium*
North East slope	20-30%/NA	NA
Bench above Black Mt. forest service road*	0-5%/N20W-N60W	*Zygadenus venenosus* *Achillea millefolium* *Ribes cereum* *Elymus spicatus* *Penstemon confertus* *Astragalus miser*

Table 1. Cont'd

Locality	Slope/aspect	Associated vascular plant species
West slope (#1)	2-40%/S20W-N45W	*Elymus spicatus* *Festuca idahoensis* *Balsamorhiza sagitatta* *Koeleria macrantha* *Ribes cereum* *Ceanothus velutinus* *Calamagrostis rubescens* *Lupinus sericeus*
West slope (#2)*	10-20%/S-S45E	*Pseudotsuga menziesii* var. *glauca* *Elymus spicatus* *Lewisia rediviva* *Artemisia tridentata* *Penstemon pruinosa* *Eriogonum heracleoides* *Lupinus sericeus*
West slope (#3)*	0-15%/S30W-S60W	*Pseudotsuga menziesii* var. *glauca* *Elymus spicatus* *Artemisia tridentata* *Balsamorhiza sagitatta* *Lewisia rediviva* *Penstemon pruinosa* *Lupinus sericeus* *Phacelia linearis*
Kilpoola Lake:		
W of Lone Pine Creek (#1)*	0%/--	*Pseudotsuga menziesii* var. *glauca* *Elymus spicatus* *Festuca idahoensis* *Eriogonum heracleoides* *Lomatium ambiguum*
W of Lone Pine Creek (#2)*	30%/N	*Pseudotsuga menziesii* var. *glauca* *Elymus spicatus* *Festuca idahoensis* *Ribes cereum* *Epilobium angustifolium* *Achillea millefolium*

*Previously unrecorded sites

Microhabitat

As noted, the transition from meadow to forest also marks the boundary of most *C. lyallii* colonies in British Columbia, although the species does occasionally establish in very open forest (Table 1). An analysis of *C. lyallii* abundance gradients at two sites indicated only weak correlations with such environmental variables as soil moisture, soil depth, litter depth, percent moss cover, and exposure. However, at a third, drier site, significant positive correlations were found between *C. lyallii* abundance and soil moisture, as well as with variables associated with soil moisture such as soil depth, litter depth, and % litter cover, suggesting that moisture may be a limiting factor for this species under certain conditions. At two of the three sites, there was a strong negative correlation between plant abundance and both slope and rockiness, although moderate degrees of slope and rockiness do not appear to have a significant effect on local density (M. Miller, unpubl. data).

Habitat Specificity

The habitat relationships described above apply to known *C. lyallii* populations in British Columbia, and do not necessarily represent the species throughout its range. In Washington state, for example, *C. lyallii* occurs at elevations ranging from about 500 m to over 1600 m, a much broader elevational span than the species exhibits in British Columbia. At the same time, many of the low elevation sites in Washington are considerably drier than any of those north of the border, and often contain entirely different plant associations. The relatively constricted distribution at the northern limit of its range therefore requires cautious interpretation. It may reflect physiological constraints (e.g., temperature or nutrient requirements), ecological conditions (e.g., lack of appropriate pollinators), history (insufficient time to disperse to all available habitat), or a combination of these.

BIOLOGY

Life History

A spring perennial, *C. lyallii* emerges each year before the snows have completely melted (i.e., before the end of April in its British Columbia habitat) and is in flower by June. Seeds are released in July and germinate the following spring.

As noted, the perennating organ is a subterranean bulb, from which the single basal leaf and flowering stem (in reproductive plants) are annually renewed. The bulb begins as a tiny structure initiated during the plant's truncated first season (when it is a seedling), eventually descending to a depth of about 10 cm. No record of the life span of the bulb is available. However, preliminary estimates of longevity based on annual increments in basal leaf width suggest that individuals of the species may live for ten or more years (M. Miller, unpubl. data).

Like all members of the genus *Calochortus*, *C. lyallii* is iteroparous, meaning that individuals reproduce several times over the course of a lifetime. Plants must be of a certain size to reproduce, usually not beginning to flower until they are 3-4 years old. In general, the larger the plant, the more flowers and fruits it will produce in a given year. However, not all adult plants flower or even increase in size every year. Some enter a vegetative state in which they produce a leaf but no flower stem; others remain reproductive but regress to a smaller size, initiating fewer flowers than the previous year. In other words, the demographic characteristics of individuals (such as fertilities and survival chances) are more likely to be related to size, or stage, than to age, a phenomenon common to many perennial plant species (Werner and Caswell, 1977). The life cycle of *Calochortus lyallii* is represented in Figure 3 as a path diagram of the various life stage transitions that are possible from one year to the next. Dormancy is one of the possible states. Also, notable is that some groups can contribute individuals to more than one stage in a given year.

Reproduction

Although bulbifery (the production of new propagules from bulb offsets) has been documented in other mariposa lilies (Fiedler, 1987), asexual reproduction has not been observed in *C. lyallii*. Instead, reproduction appears to be exclusively by seed. Results of a field experiment comparing fruit set in self-pollinated and open pollinated plants indicated that *C. lyallii* is self-compatible. However, flowers tend to be protandrous (that is, anthers shed their pollen prior to the stigma becoming receptive), a phenomenon that promotes outbreeding (M. Miller, unpubl. data). Consequently, plants probably do not self-pollinate unless pollen is transferred within plants by the movements of pollinators (G. Allen, pers. comm.).

Flower and fruit production for *C. lyallii* at three sites in 1996 and 1997 is summarized in Table 2. Rates of flower production were similar in the two years, but the proportion of flowers surviving to set fruit varied significantly, both across sites and, in particular, between years. A small black solitary bee (probably Halictidae; identity currently being determined) was a frequent pollinator of *C. lyallii* in 1996, but was absent from all observed populations in 1997. The lower fruit set for 1997 may reflect the pollinator's absence. The spring of 1997 was unusually cool and wet, a factor that may in turn have affected pollinator activity.

Table 2. Flower and fruit production rates for *C. lyallii* at three sites, Black Mountain, 1996-97

Site	Mean flower number (± s.d.) per plant		Mean % fruit set (± s.d.)	
	1996	**1997**	**1996**	**1997**
North slope (#1)	2.9 (1.5)	2.5 (1.2)	26.9 (31.9)	7.0 (16.7)
West slope (#1)	2.5 (1.1)	2.3 (0.9)	27.7 (33.6)	18.0 (32.7)
East slope (#1)	3.1 (1.4)	2.9 (2.9)	22.2 (32.1)	15.4 (28.6)

Seedling Ecology

Plants produce, on average, around 20 seeds per fruiting capsule. Seeds are gravity-dispersed and usually land close to the parent plant. Seed germination trials conducted *in situ* indicate that most seeds germinate successfully within the first year. The presence of a soil seed bank is therefore unlikely, which is consistent with findings for other liliaceous perennials (G.Allen, pers. comm.). In a home laboratory test, seeds required a period of stratification in order to germinate, but once stratified, germinated readily.

Seedlings emerge in Late April and early May, shortly after the last snow has melted. The single seedling leaf (cotyledon) remains green for a month or so before dying back to a buried bulb, at which point the young plant enters dormancy until the following spring. The life cycle graph for *Calochortus lyallii* is shown below in Figure 3.

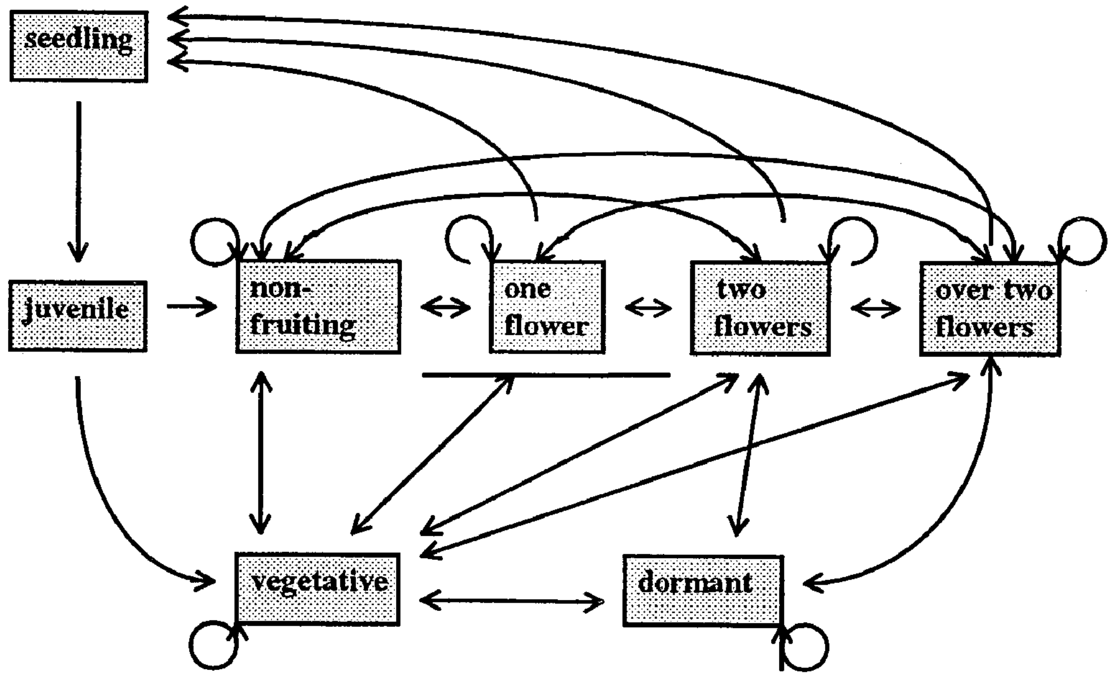

Figure 3. The life cycle graph for *Calochortus lyallii.* ['non-fruiting' = plants that flower but, due to their small size, do not set fruit; 'one flower' = plants that produce a single, potentially fruiting flower; 'two flowers' = plants that produce two flowers with the potential of fruiting; etc.]

The vast majority of seedlings establish within a short distance of adult plants; thus, seed migration is probably not a major factor in determining the local distribution and abundance of *C. lyallii*. On the other hand, seedling density in study plots was uncorrelated with seed production the previous year, suggesting that factors other than mere seed rain are affecting seedling distribution at the micro scale (M. Miller, unpubl. data). Plots that did contain seedlings tended to be characterized by greater litter cover, soil depth, and soil moisture than plots in which no seedlings were found, although this varied among sites.

Biotic Interactions

Aside from pollinator and other resource limitations, several types of negative biotic interactions involving both vertebrates and invertebrates combine to depress fruit set, and hence the amount of seed available for recruitment into the population. These include occasional grazing by insects on shoots, buds, flowers, and developing fruits, rodent (mice or vole) predation on bulbs; mechanical damage due to trampling by cattle and, to a lesser extent, damage by deer. In addition, many plants each year lose a portion of their basal leaf to invertebrate grazers. Damage ranges from single holes (about 1% of the leaf surface) to loss of the entire leaf. No correlation was found between the amount of leaf damage one year and reproductive effort (i.e., number of flowers) the next, although the full demographic consequences of leaf removal for *C. lyallii* are unknown. Given that the basal leaf is the primary photosynthetic organ of the plant, however, repeated damage to this structure could presumably affect reproductive allocation in other ways, for example by changing the balance between reproduction and growth within a single season (Fredricks, 1992).

Of the two types of mammalian interactions, only microtine predation, because it directly targets the bulb, is invariably fatal for the plant. Ungulates do not actively graze on *C. lyallii*, and although wandering cattle do much damage to emergent structures with their hooves, trampling alone does not appear to kill the plant. Nevertheless, trampling may have important consequences for reproduction, particularly in areas regularly visited by cattle. At the 'East (#1)' site, for example, where 17% of all flowering stems were trampled during the course of the 1996 flowering season, cattle visitation had a significant negative impact on the average per capita seed production of the population (M. Miller, unpubl. data). Not studied here, but also of concern, is the impact that soil compaction may have on seed germination rates and seedling survival as a consequence of changes both to surface soil structure and soil moisture status.

POPULATION SIZES AND TRENDS

Eleven *C. lyallii* localities have been reported for Canada, all of them on the height of land between Richter Pass and the U.S. border a few km west of Osoyoos in south central British Columbia (Table 3). All of the known *C. lyallii* colonies occur within a few km of one another, while some are separated by a distance of less than 0.2 km. Due to pollinator activity, gene flow between these more proximate colonies almost certainly exists. Therefore, if one accepts the standard ecological definition of a population as a group of interbreeding individuals sharing a common gene pool, the effective number of populations is probably considerably lower than 11, and may be as few as 3 or 4.

Patches number anywhere from a few hundred to many thousands of individuals, depending on the location (Table 3). The largest population extends several hundred metres down an open, meadowed slope on the north side of Black Mountain and contains upwards of half a million plants. Sizable populations occur in similar habitats on the east and west slopes of Black Mountain. The smallest recorded colonies, some measuring only a few metres across, are found either on dry shallow outcrops, in forest openings, or on disturbed sections of rangeland. These small sites also tend to have the lowest densities of plants, possibly reflecting marginal habitat conditions. Alternatively, these colonies could be smaller simply because they have established more recently and are still in the process of expanding.

Population size is only one element of population status; taken alone, it does not reveal anything about the actual dynamics of the population—whether or not, for instance, it is growing in numbers, declining, or holding steady. In order to make projections regarding population performance, some information about current population structure, and about stage-specific fecundity and survivorship, is also required. Construction of a stage-based projection matrix for *C. lyallii* is currently underway, using demographic data gathered from 1996-1997. As a preliminary snapshot of current population status, Figure 4 shows the relative stage distributions of

C. lyallii at three sites in both 1996 and 1997. Note that some individuals observed in 1996 did not reappear in 1997; these plants either died or became dormant during the census period. Note also that the number of juveniles entering the population in 1997 was more or less comparable to the proportion that 'exited,' suggesting not only that recruitment is occurring, but that it is occurring approximately at replacement rates. Because these numbers represent the events of a single year only, however, they should be interpreted with appropriate caution. It is conceivable, for example, that they reflect after effects of the 1994 forest fire on Black Mountain, the short term significance of which for the population dynamics of *C. lyallii* is uncertain.

Table 3. Collection dates and population sizes for *Calochortus lyallii* sites in British Columbia

Collection Site	Last Observation	Collector	Population (no./area)
Black Mt.:			
East slope (#1)	1997	Miller	15,000+/0.3 ha
East slope (#2)	1997	Miller	2500+/0.1 ha
North slope (#1)	1997	Miller	400,000+/1.9 ha
North slope (#2)	1997	Miller	6500+/0.3 ha
North East slope	1995	Furness	100-150/100 sq m
Bench above Black Mt forest service road	1997	Miller	7200+/0.15 ha
West slope (#1)	1997	Miller	65,000+/0.5 ha
West slope (#2)	1997	Miller	200+/400 sq m
West slope (#3)	1997	Miller	39,000+/0.8 ha
Kilpoola Lake:			
West of Lone Pine Creek (#1)	1997	Miller	1200+/400 sq m
West of Lone Pine Creek (#2)	1997	Miller	40+/50 sq m

The earliest observation of *C. lyallii* in British Columbia, as recorded at the CDC, was by Steve Cannings in 1978. Information available about a single collection made previous to this (Owenby, 1940) is not sufficiently specific to determine the status of *C. lyallii* populations in terms of historical trends. All that can be assessed is their presence or absence.

LIMITING FACTORS AND THREATS

The great majority of known *C. lyallii* populations occur on a single contiguous section of provincial Crown Land encompassing the upper slopes of Black Mountain. This land, which is administered by the British Columbia Ministry of Forests, is surrounded down slope by a matrix of private ranch holdings and is itself licensed both for grazing and timber harvesting. The effect that trampling by cattle has on *C. lyallii* plants, particularly in terms of reproductive output, was noted above. Although regulations exist which limit the intensity and timing of grazing on Crown range, it appears that grazing pressure on Black Mountain has, if anything, increased in recent years, as wandering livestock from local ranches take advantage of the flush of new growth created in the wake of the fire that swept through the area in 1994.

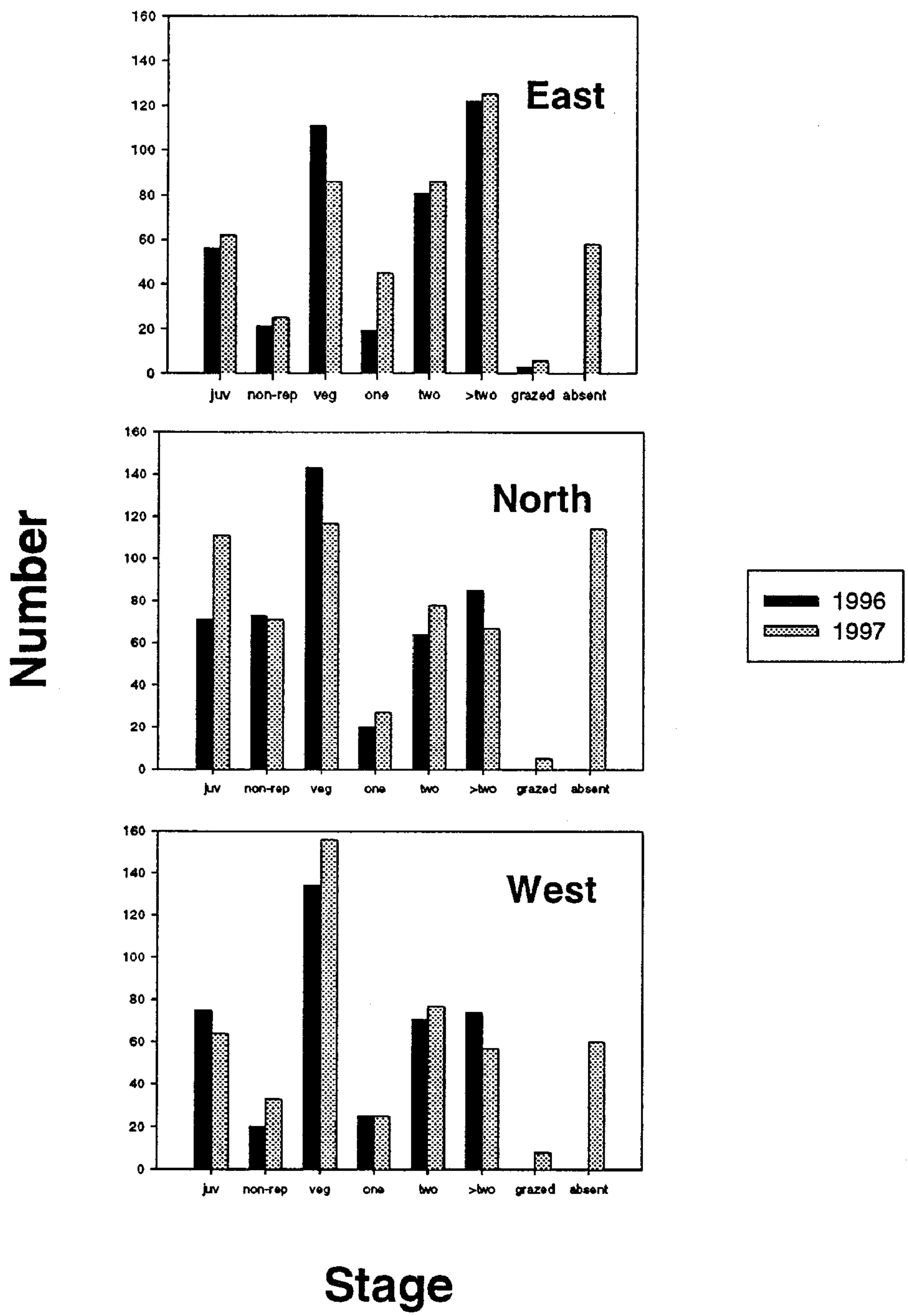

Figure 4. Population stage structure of *C. lyallii* in 1996 and 1997 at three separate locations on Black Mt. [Stages determined according to size (basal leaf width) and reproductive status: 'juv' = juveniles (pre-reproductive); 'non-repro' = flowering but not fruiting; 'veg' = vegetative adults; 'one', 'two','>two' =number of flowers initiated; 'grazed' = flowering shoots removed by insects; 'absent' = dead or dormant in 1997.]

In 1995, ‘salvage logging’ operations cleared away large sections of burnt out forest on the north and east slopes of Black Mountain, further facilitating livestock access to several *C. lyallii* sites. In some places, clearcuts extend to within 100 m of *C. lyallii* colonies, raising the additional spectre of invasions by weedy exotics. In fact, the recent coincidence of fire, grazing, and logging on Black Mountain could prove to have serious consequences for the native plant communities there. Already, a cocktail of troublesome weeds, including *Cirsium arvense* (Canada thistle), *Cynoglossum officinale* (hound’s- tongue), and *Verbascum thapsus* (mullein) have gained a foothold in some areas, while at least one *C. lyallii* site has been invaded by the weeds *Filago arvensis* (filago) and *Lactuca serriola* (prickly lettuce).

Ironically, it is not logging *per se* but the replanting that was done following logging that has created the most direct threat to *C. lyallii* habitat on Black Mountain. During the latter procedure, dozens of natural meadow openings, at least one of which contains a previously unrecorded population of *C. lyallii*, were mistakenly targeted for reforestation and systematically planted with coniferous tree seedlings. A number of these seedlings were subsequently removed by hand, but many remain where they were placed. If permitted to grow to size, these introduced canopy species will almost certainly have an altering effect on the region’s grassland-meadow system, which at present contains significant patches of potential *C. lyallii* habitat.

The two Kilpoola Lake sites, which are situated on a private ranch lease 1.5 km south of Black Mountain, also display signs of recent disturbance. A logging road, blazed into the area to access burnt timber following the 1994 fire, passes within a few metres of both colonies, potentially exposing them to hazards from other forms of off-road, mechanized traffic. Immediate impacts of the logging itself are unclear, given that these sites were only recently ‘discovered’ and their condition prior to logging unknown. However, their relatively small size as well as their isolation from other populations may make these colonies especially vulnerable to disturbance, particularly in light of the fact that the ridge on which they occur comprises the most sparsely forested of all the *C. lyallii* sites and is readily accessed by livestock.

Aside from anthropogenic impacts and habitat loss due to natural forest succession, a variety of biotic factors may have a role in limiting *C. lyallii* distribution and abundance at the northern edge of its range. Reproductive success at the Black Mountain sites, for example, appears to be related to the availability of a specific pollinating insect. Other factors likely to have an effect on *C. lyallii* demography include fruit predation by insects, bulb predation by small mammals, and trampling by deer.

SPECIAL SIGNIFICANCE OF THE SPECIES

The hill range to which *C. lyallii* is restricted is part of a larger upland system that includes Mount Kobau, Kilpoola Lake, Chopaka, and the International Grasslands. This region has long been recognized as an area of “exceptionally high natural diversity that is in danger of degradation and loss of habitat and associated wildlife, invertebrate and plant species" (Bryan, 1996). Located at the northern extreme of the Western Great Basin ecosystem, the area hosts an inordinate proportion of the province's rarest species, including several that occur nowhere else in Canada. It also contains one of the largest remaining tracts of sagebrush grassland in the south Okanagan (Bryan, 1996). In recognition of its uniqueness, the Mount Kobau/Kilpoola Lake/Chopaka region has recently been accorded 'Goal 1' priority for protected status by the British Columbia government's Land Use Coordination Office (K. Lewis, pers. comm.).

Calochortus lyallii is itself taxonomically unique in British Columbia, being the only *Calochortus* species of three found in the province to belong to subsection Nitidi, a distinct group of species within the section Eucalochortus (Owenby, 1940). British Columbia populations of *C. lyallii* are separated from the closest known Washington population 20 km to the south by the Similkameen River Valley. Consequently, any further dispersal into Canada from this part of the range would have to be effected through the air. However, the very limited number of *C. lyallii* occurrences north of the border suggests that colonization events of this type are quite rare.

A number of compelling arguments have been made for protecting populations of species at the limits of their range (for a good summary, see Lesica and Allendorf, 1995). Empirical evidence suggests, for example, that peripheral populations are often genetically and morphologically divergent from central populations (Lesica and Allendorf, 1995). The ability of a species to adapt to changing conditions, and thus its long-term conservation, may depend on the protection of these genetically distinct populations. Northern peripheral populations may turn out to have particular importance as sources of migration in the event of global warming (Primrack and Miao, 1992). At the same time, their geographical isolation and the fact that they tend to occur in less suitable environments than more central populations (Lawton, 1993) mean that peripheral populations are often more prone to extirpation due to stochastic or demographic events.

Whether or not any or all of these arguments apply to *C. lyallii* is unknown. However, the almost certain reduced gene flow between *C. lyallii* colonies in British Columbia and those to the south merits interest as well as concern.

Where *C. lyallii* does occur it comprises a major portion of the herbaceous cover, with one of the highest relative densities of any species in the community (Table 3). Often several hectares in size, *C. lyallii* patches form an impressive visual component of the local landscape. Given the sheer density of the patches, it is probable that they also make a substantial contribution to the local energy balance, both in terms of water and nutrient cycling and as a source of energy for a variety of vertebrate and invertebrate species. This may be especially true given *C. lyallii* 's bulbiferous habit, for bulbs not only store energy harvested through photosynthesis; they also control the rate of its release from one year to the next, thus lending *C. lyallii* a potentially important role in moderating energy fluxes during environmentally sub-optimal years.

EVALUATION AND PROPOSED STATUS

Existing Protection or Other Status

International Status

C. lyallii is not covered under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). It is not listed or proposed for listing under the U.S. Endangered Species Act; nor is it listed in the IUCN Red Data Book. It has been globally ranked by the U.S. Nature Conservancy as "G3," defined as "rare or uncommon (typically 21-100 occurrences); it may be susceptible to large scale disturbances; e.g. such as the loss of extensive peripheral populations." In the southern portion of its range, central Washington, it occurs infrequently but is locally abundant when found.

National and Provincial Status

The B.C. Conservation Data Centre ranks *C. lyallii* as "S1," defined as "critically imperiled because of extreme rarity (5 or fewer extant occurrences of very few remaining individuals) or because of some factor(s) making it vulnerable to extirpation or extinction" and has placed it on the Ministry of Environment, Lands and Parks Red list (Douglas et al. 1998a).

Assessment of Status and Authors' Recommendation

Within British Columbia, *C. lyallii* is confined to a single height of land (Black Mountain and surroundings) in extreme southcentral British Columbia. Its habitat of grassy openings in Douglas-fir forest at elevations from 900 m to 1300 m are relatively common in the high country south of Richter Pass, so that there does not appear to be a shortage of suitable habitat, at least locally, for this species. Aside from gravity, *C. lyallii* possesses no obvious mechanism for dispersing its seeds, and this may be an important factor limiting its ability to establish new populations at unoccupied sites.

Despite recent disturbances from silvicultural activities and ongoing disturbances associated with livestock grazing, there is no evidence at present to suggest that the *C. lyallii* population in British Columbia is in decline or imminently in risk of extirpation. Individual colonies appear in general to be robust, both in terms of numbers of plants (median estimated patch size = 6500+ individuals) and the proportion of new recruits present. Although forest succession, both natural and human-induced, poses a potential long-term threat to these colonies, a recent fire on Black Mountain and neighboring hills has had the immediate effect of increasing the amount of open habitat in the area. Meanwhile, the same feature that helps to make *C. lyallii* fire resistant—its bulbiferous habit—may also buffer the species against other short-term, above-ground disturbances such as trampling.

On the other hand, the level of perturbation that has been visited on Black Mountain in recent years is likely unprecedented in scale. Since 1995, the habitat there has been fragmented by 3 separate cut-blocks, each measuring several hectares, and further disturbed by the planting of trees in previously untreed meadows. At the same time, approximately 150 head of cattle continue to be turned out each spring to graze in the post-burn landscape, with uncertain consequences for the remaining habitat. Unfortunately, the very recency of these developments makes it too soon to assess their long-term impact on extant *C. lyallii* populations, especially in the absence of historical information on population numbers and/or extent to serve as a benchmark against which to compare the present performance of the species. Regardless of present population status, only time may tell us whether *C. lyallii* has the ability to cope with such rapid changes to its habitat.

There is little known, even in a general sense, about the factors constraining a species at the extreme limit of its range (only that they are likely to be complex). It may, for instance, be the inability to perform above some demographic threshold, determined by a combination of climatic, environmental, and physiological constraints, that prevents *C. lyallii* from migrating further north or, alternatively, from expanding its local range (Carter and Prince 1981). If so, then any anthropogenic source of demographic variability, such as the observed impact of grazing on *C. lyallii* reproductive performance, becomes immediate cause for concern. Alternatively, if seed dispersal, rather than reproduction, is the main factor limiting *C. lyallii* distribution locally, then the preservation of unoccupied but potential *C. lyallii* habitat on Black Mountain and further north will assume paramount importance as original sites become compromised by disturbance.

Of the 11 known *C. lyallii* colonies in British Columbia, two occur on privately held land above Lone Creek, whereas the other nine are on provincial Crown land administered by the British Columbia Ministry of Forests and encompassing about 1000 contiguous hectares on the upper slopes of Black Mountain. Designating this area as an ecological reserve would not only help to secure habitat for one of Canada's rarest species, it would also be protecting a rich and diverse ecosystem, characterized by an abundance of habitat types and a plant assembly found nowhere else in the province. This assembly includes at least two additional Red Listed species, along with some fine examples of relatively pristine bunch grass, only a few pockets of which remain in southern British Columbia. At the very least, Black Mountain and surrounding area could serve as an excellent model for the application of ecosystem management principals now being developed in the conservation literature (Noss, 1992).

In an earlier paper (Miller and Douglas, 1999) the authors recommended that *C. lyallii* be ranked as threatened in Canada. Its confined range, the close proximity of all known colonies to one another, and the small spatial extent of each patch combine to make this species highly vulnerable to disruption from both stochastic environmental events and human encroachment.

TECHNICAL SUMMARY

DISTRIBUTION

Extent of occurrence: 150 km^2

Area of occupancy: ca. 4.1 ha

POPULATION INFORMATION

Total number of individuals in the Canadian population: 536 740

Number of mature reproducing individuals in the Canadian population: unknown

Generation time: years)

Total population trend: stable

Rate of decline (if appropriate) for total population: 0% in 10 years or three generations (whichever is longer)

If data are only available for a period shorter than 10 years or three generations, ______% decline in _____years.

Number of known populations: 11 colonies (possibly ony 3-4 pops.)

Is the total population fragmented? YES

number of individuals in smallest population: 40+

number of individuals in largest population: 400 000+

number of extant sites: 11

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

Does the species undergo fluctuations in numbers?_____YES __NO ?

If yes, what is the maximum number? ____________

minimum number?____________

Are these fluctuations greater than one order of magnitude?___YES ___NO

LIMITING FACTORS AND THREATS

Silvicultural practices, including tree planting threaten *Calochortus lyallii*. In addition, trampling by livestock and exotic species are limiting factors. Herbivory by insects and small mammals could impact populations. Finally, pollinator availability and poor seed dispersal are intrinsic biological threats.

RESCUE POTENTIAL

Does the species exist outside Canada? YES

Is immigration known or possible? YES

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

Would sufficient suitable habitat be available for immigrants? YES

ACKNOWLEDGEMENTS

Many thanks to Dr. Gerry Allen and Dr. Joe Antos for their advice and suggestions during the course of this study. Thanks also to Rob Webster and Anthea Bryan, both of whom were valuable sources of local information, and to the Nature Trust of British Columbia for making accommodation available at Kilpoola Lake. Funding was provided by the British Columbia Conservation Data Centre.

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RECORD OF FIELDWORK CONDUCTED AND OTHER INFORMATION SOURCES

Fieldwork

Unless otherwise noted, the information in this report is based on data gathered by the senior author as part of an PhD study of the habitat requirements and comparative demography of *C. lyallii* and a more common, widespread relative, *C. macrocarpus*. Research was conducted over the spring and summers of 1996 and 1997, with a third field season scheduled for 1998. Approximately 1300 individual plants were marked and mapped within 95 permanent plots at three sites representing a range of habitat types. Plots were then censused twice each year, once during flowering season and again during fruiting. Data were collected on plant size (including growth and survival from one year to the next), numbers of flowers and fruits, and on both vertebrate and invertebrate grazing. Transects were also established to collect data on *C. lyallii* abundance in relation to microsite features such as litter and substrate characteristics, moisture, and cover of associated species. Construction of a stage-based projection matrix model for *C. lyallii*, based on the first two years' data, is currently underway.

In addition to making several searches of Black Mountain, the first author visited potential *C. lyallii* sites at Kilpoola Lake, Blue Lake, the International Grasslands, west Chopaka, and on Mount Kruger. These surveys yielded six new *C. lyallii* records. Because it was not feasible to count every individual in the larger colonies, population abundances at these sites were estimated using the average density of plants in transects at the three main study sites. Consequently, the population estimates that have been provided are, in some cases, tentative.

Collections Consulted

Royal British Columbia Museum, Victoria, B.C.; University of Victoria Herbarium, Victoria, B.C.

Knowledgeable Individuals

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4) Rob Webster, Osoyoos resident, Osoyoos, B.C.
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6) Jane Thornton, Range Management, British Columbia Ministry of Forests, Penticton, B.C. V2A 7C8
7) Jerome Jang, Resource Officer, Silviculture, British Columbia Ministry of Forests, Penticton, B.C. V2A

Summary of Materials on File

All element occurrence records and maps for *C. lyallii* are available at the British Columbia Conservation Data Centre in Victoria. Slides of *C. lyallii* and its habitat are available upon request from the senior author.

THE AUTHORS

Michael J. Miller has a B.Sc. in biology from the University of Victoria. At the present time he is in a PhD program in biology at the University of Victoria. Michael's thesis research deals with the biology and ecology of *Calochortus lyallii.*

George W. Douglas has an M.Sci. (Forestry) from the University of Washington and a Ph.D (Botany) from the University of Alberta, Edmonton. George has worked with rare plants for over 20 years. He was senior author of The Rare Plants of the Yukon (1981), co-authored The Rare Plants of British Columbia (1985) and was senior author of the Rare Native Plants of British Columbia (1998). He is also the senior editor for the Illustrated Flora of British Columbia (1998-2000) and has been the program botanist for the British Columbia Conservation Data Centre since its inception in 1991. George has written or co-written 15 COSEWIC status reports during this period.