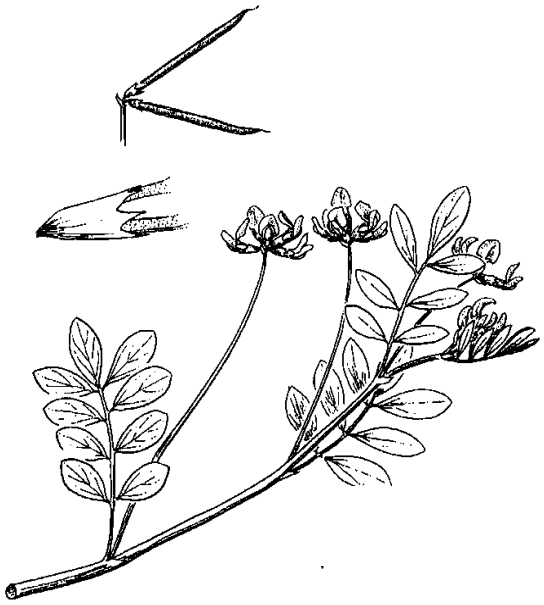
COSEWIC
Assessment and Status Report

on the

Bog Bird's-foot Trefoil
Lotus pinnatus

in Canada



ENDANGERED
2004

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:

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Bog bird's-foot trefoil — line drawing in Hitchcock et al. 1961 and Douglas et al. 1999.

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COSEWIC
Assessment Summary

Assessment Summary – May 2004

Common name
Bog bird's-foot trefoil

Scientific name
Lotus pinnatus

Status
Endangered

Reason for designation
Few small fragmented populations that are geographically restricted and found within wetland meadows of limited occurrence and considerably disjunct from the main range of the species in the northwestern United States. Populations are at risk from continued habitat loss and encroachment of invasive species and from recreational off-road vehicular activities with the likelihood of significant losses due to planned commercial development of habitat supporting the only sizeable remaining population.

Occurrence
British Columbia

Status history
Designated Endangered in May 2004. Assessment based on a new status report.

COSEWIC
Executive Summary

Bog Bird's-foot Trefoil
Lotus pinnatus

Species information

Lotus pinnatus (bog bird's-foot trefoil) is a low-growing, multi-stemmed perennial herb with compound, pinnate leaves. The pea-like, yellow and cream-coloured flowers are borne at the end of a long stalk arising from the angle between the stem and leaf stalk. It is distinguished from other *Lotus* species by its perennial habit, papery stipules and yellow and white flowers. The umbel stalks are bractless or with a single membranous bract.

Distribution

Lotus pinnatus is restricted to the west coast of North America and ranges from southeastern Vancouver Island, west of the Cascade Mountains and along the Columbia River Gorge from northwestern Washington to central California. This species also occurs sporadically eastward to Idaho.

Habitat

British Columbia populations of *Lotus pinnatus* occur in moist open meadows along the margins of creeks, in wet ditches or in seepages, where underground water comes to the surface. In all cases, the soils are shallow (< 15 cm), over gently sloping sandstone or conglomerate bedrock with abundant moisture during the growing and blooming period. The most commonly associated species include *Mimulus guttatus, Triteleia hyacinthina, Plectritis congestus, Plagiobothrys scouleri, Veronica beccabunga ssp. americana* and *Montia parvifolia*.

Biology

Lotus pinnatus is a perennial plant that sends up several shoots each spring. The flowers emerge in June and mature by early July, before summer moisture deficits reduce the plant's productivity. Capsules begin to dehisce by mid-July, dispersing mature seed until August. Flowers likely require cross-pollination to set viable seed, though pollinators have not yet been identified. The seeds have a hard seed coat that may delay the germination of some seed for several months or years.

Population sizes and trends

There are seven known populations of *Lotus pinnatus* in Canada. Historic populations at two other sites could not be relocated and are likely extirpated. The total number of plants in Canada is between 1500 and 2000.

Limiting factors and threats

The viability of *Lotus pinnatus* in Canada is a concern due to the small number of known populations, habitat specificity, isolation from Washington populations, limited seed dispersal and the lack of protection on private land. Alterations to hydrology and erosion arising from intensive recreational use of primary habitat by off-road vehicles and invasive species are the main concerns for British Columbia populations.

Special significance of the species

The populations of *L. pinnatus* in British Columbia are at the northern extent of the geographic range of the species. Isolated peripheral populations are often genetically and morphologically divergent from central populations. The ability of a species to adapt to changing ecological conditions and therefore, its long-term survival, may rest on the conservation of these potentially genetically distinct peripheral populations (Lesica and Allendorf 1995).

Existing protection or other status designations

Provincially, *Lotus pinnatus* is red-listed (critically imperiled because of extreme rarity) as designated by the British Columbia Conservation Data Centre. Four occurrences for *Lotus pinnatus* are located on land that is privately owned; one site is protected within Ecological Reserve #142.

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. 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 and include 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 organizations (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biosystematic Partnership, chaired by the Canadian Museum of Nature), three nonjurisdictional 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 (AFTER MAY 2004)

Species	Any indigenous species, subspecies, variety, or geographically or genetically distinct 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 that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
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.

Environment Canada	Environnement Canada
Canadian Wildlife Service	Service canadien de la faune

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

COSEWIC Status Report

on the

Bog Bird's-foot Trefoil

Lotus pinnatus

in Canada

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2004

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SPECIES INFORMATION

Name and classification

Scientific name:	*Lotus pinnatus* Hooker
Synonyms:	(from Hitchcock *et al*. 1961; Scoggan, 1978)
	Hosackia bicolor Douglas ex Benth.
	Hosackia pinnata (Hook.) Abrams
	Lotus bicolor (Douglas ex Benth.) Frye & Rigg
Common names:	bog bird's-foot trefoil, bog deer-vetch, meadow deer-vetch, meadow bird's-foot trefoil
Family:	Fabaceae; Legume family
Major plant group:	Angiospermae

During classical times, the Greek word 'lotos' was applied to four different plants, including *Nymphaea lotus* L., the sacred water lily used by the Egyptians as a food source (Kirkbride 1999). In Homer's Odyssey, the hero Ulysses almost lost his crew when they became intoxicated by the honey-sweet fruit of *Zizyphus lotus* L. in the land of the Lotus-Eaters. Camarario (1588) was the first to apply the Latin name 'lotus' to a trefoil in his "*Hortus Medicus*".

Considerable disagreement has existed among systematists about whether North American species of *Lotus* should be included in the genus *Lotus* or kept distinct in a separate genus *Hosackia*. As a result, specimens of North American species have been classified under both genera and may be found under either of these names in many herbaria (Zandstra and Grant 1968).

Lotus pinnatus was first described by Hooker in 1829. Later that same year, with a wealth of new material collected by David Douglas from western North America, Bentham re-described the species as *Hosackia bicolor* Dougl. In Bentham's view, *L. pinnatus* had the habit, inflorescence and fruit of *Lotus*, but the position of the wings, capitate stigma, foliaceous stipules and pinnate, not ternate, leaves were sufficiently distinct to justify the placement of several North American species, formerly referred to *Lotus*, in *Hosackia*. Bentham established a new section, *Microlotus* Benth - for the New World species of *Lotus* with single-flowered inflorescences and 3- to 5-foliate leaves without stipules (Bentham 1929).

Subsequently, Torrey and Gray (1838), Gray (1863) and Watson (1876) placed all North American species in *Hosackia*, though each treatment varied as to the number of sections and the taxonomic position of certain species. Greene (1890) supported the broad and inclusive Linnaean concept of *Lotus* and transferred all the New World species back to *Lotus.* Taubert (1894) and Brand (1898) emphasized different vegetative and floral characteristics in distinguishing *Lotus* from *Hosackia*, but both placed all North American species in *Hosackia*. With the exception of Abrams (1944) who maintained the Pacific northwest species in *Hosackia*, all subsequent floristic treatments (Pojar, 1999; Polhill, 1981, 1994; Isely, 1981; Hitchock et al. 1961, Callen

1959; Ottley 1923, 1944, 1951) have maintained the North American species in *Lotus, sensu lato* of Linnaeus, as there were no definitive characters to distinguish them generically from the European species of *Lotus*.

Description

Bog bird's-foot trefoil is a low-growing, perennial herb from a thick taproot and short rhizome with many erect to spreading stems, from 15-60 cm long (Figure 1, Pojar 1999). Ottley (1923) and Hitchcock *et al*. (1961) also provide a detailed description of *L. pinnatus* with illustrations. The lower stems are often spongy-thickened and whitish. The leaves are 4-8 cm long, alternate, stalked and pinnately compound with 5-9 elliptic, oblong or narrowly egg-shaped leaflets, each 1-2.5 cm long. The stipules are membranous, obovate and 3-10 mm long (Pojar 1999).

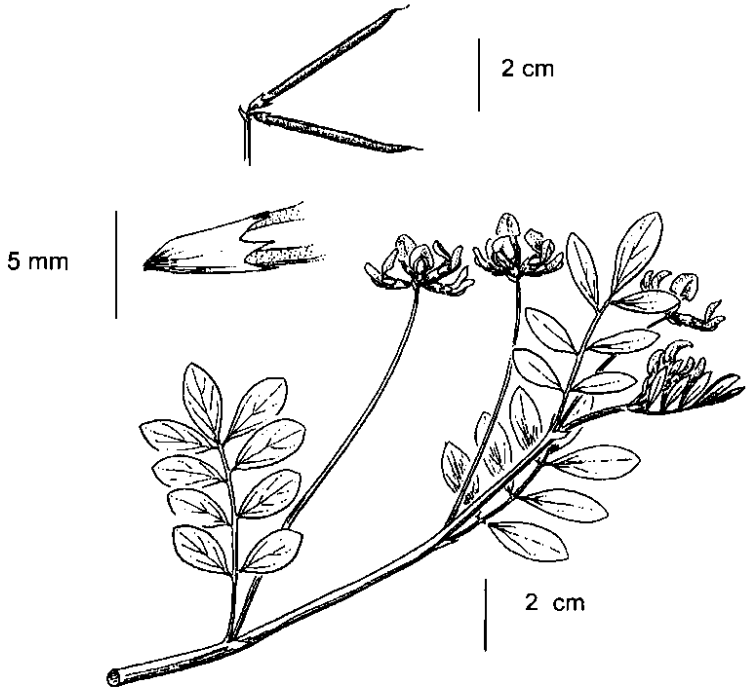

Figure 1. Illustration of *Lotus pinnatus* (line drawing in Hitchcock *et al*. 1961 and Douglas *et al*. 1999).[1]

[1]This illustration has been reproduced with permission from University of Washington Press.

The inflorescence is a compact, stalked, axillary umbel of 3 to 12 pea-like flowers. The umbel stalks are bractless or with a single membranous bract. The corollas are from 10-15 mm long with a yellow banner and keel and creamy-white wings. The keel petals are fused along one edge that is elongated into a well-defined beak towards the outside of the inflorescence. The ten stamens are diadelphous with 9 stamens fused into a tube enclosing the ovary and a single free stamen opposite the banner petal. Five stamens, including the free one opposite the banner petal, have slender filaments and their anther is dorsofixed, that is, attached to the filament on the back near the base. They are shorter than, and alternate with, the other five stamens belonging to the fused group. The filament of the longer stamens is dilated below the anther, which is basifixed (attached to the filament at the base). The anther and dilated region of the five longer filaments are enclosed within the beak of the keel petals. Prior to anthesis, pollen is released into the beak of the keel petals (Kirkbride 1999).

The calyx is tubular and 4-8 mm long with triangular-lanceolate teeth that are all much shorter than the tube. The upper two calyx lobes are joined most of their length and are merely notched between them. The lower calyx lobes are awl-shaped. The linear seed pods range from 3-6 cm in length and 1.5-2 mm wide and contain 5-20 glabrous seeds (Pojar 1999). The seeds are cylindrical, glossy, dark brown to black, mottled with olive and about 1.5 mm long. For a technical description of the seed, see Arambarri (1999).

In the field, there are several species that superficially resemble *L. pinnatus*. *Vicia* species are often present in similar habitats, but the leaves are smaller in size than those of *L. pinnatus* and the terminal leaflet in *Vicia* spp. (vetches) is represented by a tendril. *Lotus formosissimus* (seaside bird's-foot trefoil) looks very similar to *L. pinnatus* except the wing petals of *L. formissimus* are pinkish-purple, while those of *L. pinnatus* are cream-colored. Though a trifoliate bract usually subtends the flowers of *L. formosissimus*, bracts were sometimes absent in field specimens or only a unifoliate bract was present (Ryan and Douglas 1994). Although *L. pinnatus* and *L. formosissimus* could be confused if the plants are immature or not in flower, the two species do not overlap in their distribution in British Columbia. Listed as Endangered by COSEWIC, *Lotus formosissimus* is known only from the Victoria area and nearby islands where it occurs in various xeric habitats, ranging from open exposed grass-dominated meadows to exposed steep rocky sites with *Quercus garryana* (Garry oak) (Ryan and Douglas, 1994). *Lotus pinnatus* is found only in the Nanaimo area on Vancouver Island, where it occurs in moist soil on exposed, coastal lowland areas. *Lotus corniculatus* (bird's-foot trefoil) occasionally grows in wet places, is an introduced species and is usually found in drier, disturbed sites. Also, *L. corniculatus* has completely yellow flowers and its leaflets are smaller and more blunt than the other trefoils (Guard 1995).

DISTRIBUTION

Global range

Lotus pinnatus occurs in western North America from Vancouver Island, British Columbia, west of the Cascade Mountains and along the Columbia River Gorge from northwestern Washington to central California and sporadically eastward to Idaho (Isely 1993, Pojar 1999) (Figure 2, Pojar 1999).

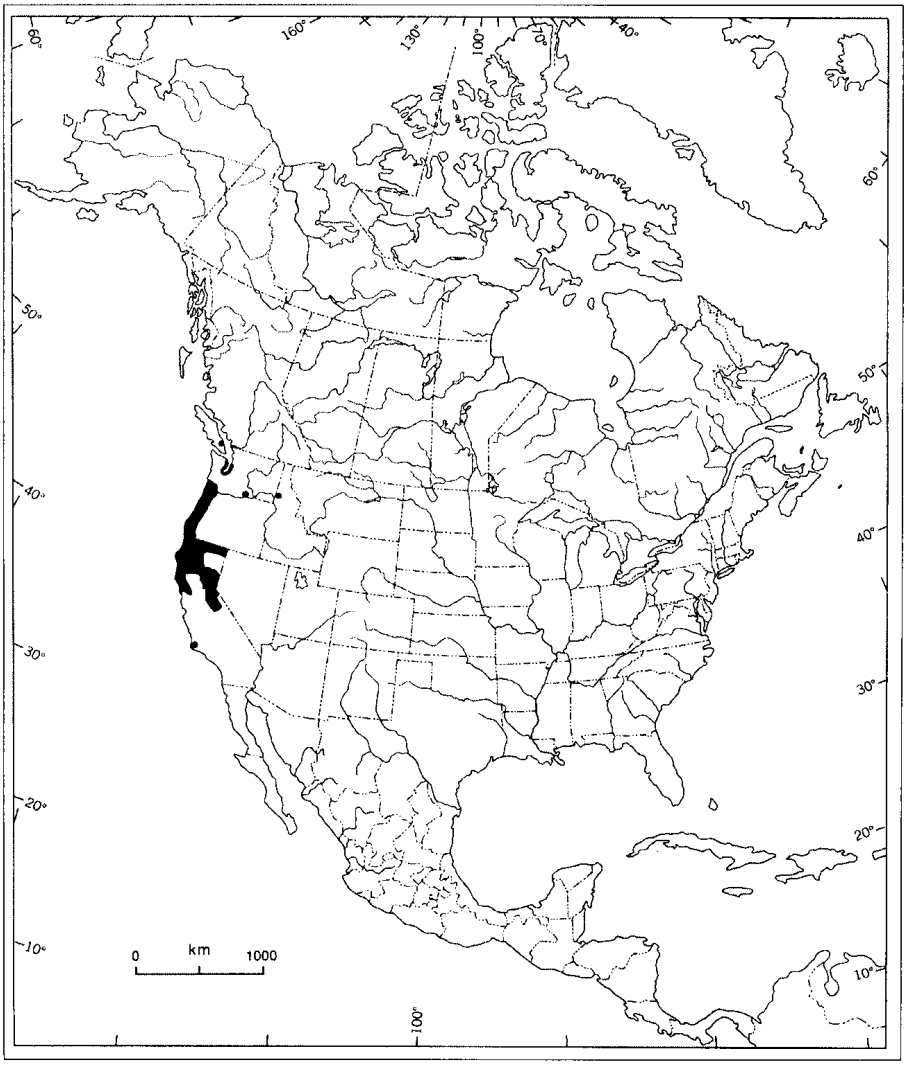

Figure 2. Distribution of *Lotus pinnatus* in North America.

Lotus pinnatus has a disjunct distribution in Washington State, where it is found inland as far as Klickitat County (southern Washington), as well as on the coast (University of Washington Herbarium Database, 2002). Throughout western Oregon,

this species occurs in the interior valley west of the Cascade Mountains from Clackamas County in the northern part of the state south to Josephine County adjacent to California (Vrilikas pers. com. 2003). In California, *L. pinnatus* is known from the Klamath Range, the northern California Coast Range, the Cascade Range, the northern Sierra Nevada Range and Contra Costa County (Isely, 1981). Originally described from northern California, *Lotus pinnatus* has also been reported from Santa Barbara County in southern California (CalFlora 2003).

Canadian range

In Canada, *Lotus pinnatus* is known from seven extant populations within a small area on the east coast of Vancouver Island near Nanaimo, British Columbia (Pojar 1999). Each of these occurrences, ranging from Harewood Plains, south of Nanaimo to the Woodley Range Ecological Reserve, northeast of Ladysmith, and to Gabriola Island, east of Nanaimo (Figure 3) were verified by the author during surveys in 2003. Despite detailed searches in 2003, two additional occurrences in Nanaimo known from historical records were not relocated.

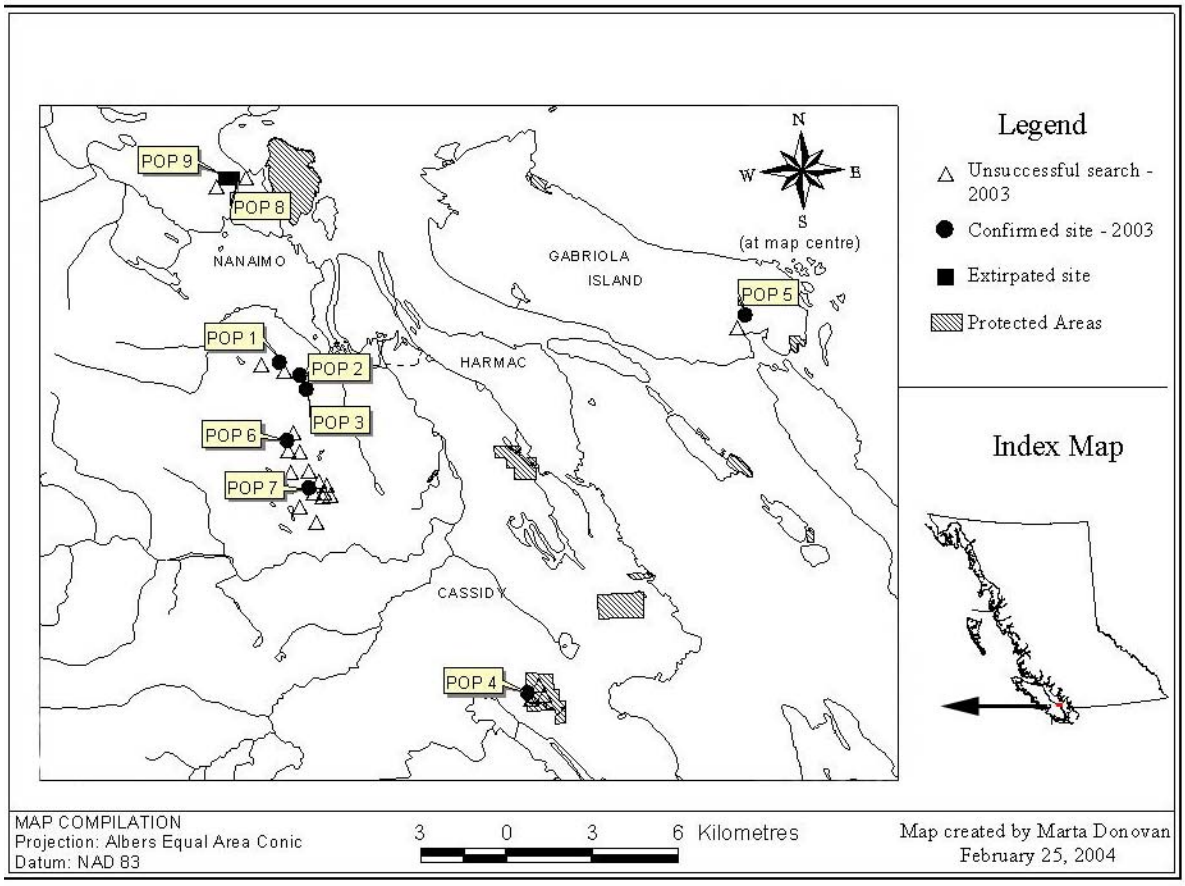

Figure 3. Distribution of *Lotus pinnatus* in British Columbia.

The Canadian range of *L. pinnatus* is restricted due to the limited availability of its preferred habitat (open seepages at the edge of grassy meadows). GIS tools were used to calculate the terrestrial portions of a minimum convex polygon encompassing all sites of occurrences. The extent of occurrence of the species in Canada is approximately 100 km^2 (10,000 ha). However, total area of occupancy is less than 1 hectare.

Approximately eight days of fieldwork, conducted in June 2003 during peak flowering, focused on the confirmation of known populations, and the search for new ones. As most known populations in British Columbia are found in vernally moist sites adjacent to grassy meadows, searches for new populations focused on these features. Using aerial photographs and topographic maps, areas of ephemeral drainage at the margins of grassy meadows in the vicinity of known sites at Woodley Range, White Rapids Rd. and Gabriola Island were identified and were accessed wherever possible. An area of approximately 300 hectares was searched. It is possible that additional populations of *L. pinnatus* remain to be discovered, since some of this potential territory is under private ownership with limited access.

Lotus pinnatus is a conspicuous and highly visible plant that would not be easily overlooked if flowering, even in the course of casual botanical inventory. Despite 50 - 60 hours of careful searching in potential habitat over the past eight years by skilled botanists, Adolf Ceska, George Douglas, Matt Fairbarns and Hans Roemer, *L. pinnatus* has not been found at any other localities throughout the species' extent of occurrence. These searches have included: Harmac, Mount Benson and forest openings along White Rapids Road.

In 2003, a GIS analysis using information for the Nanaimo Lowland Ecosection collected by the Sensitive Ecosystems Inventory (SEI)[2] and mapped at a scale of 1:20,000 was used to identify potential sites for investigation. The two sensitive ecoysystem categories that correspond most closely to the type of habitat capable of supporting populations of *Lotus pinnatus* were the Terrestrial Herbaceous (HT) and Wetland (WN) units (Ward *et al*. 1998).

The HT category includes natural grasslands and bryophyte-dominated ecosystems that occur in small patches, often in a mosaic of several types of herbaceous communities and sometimes within a larger forested site. Typically thin-soiled, most HT sites are dry, open and exposed. However terrestrial herbaceous ecosystems sometimes contain highly specialized microhabitats, including vernal pools and seepage areas that are hotspots for plants of conservation concern (McPhee *et al*. 2000). Several native plant species typically found in HT ecosystems, such as *Mimulus guttatus, Plectritis congesta, Triteleia hyacinthina* and *Montia parvifolia*, are common associates of *Lotus pinnatus*. Potential microhabitats with suitable seepage were considered most likely to occur in HT sites with rock outcrops as a dominant feature

[2]The Sensitive Ecosystems Inventory (SEI) is a joint federal/provincial initiative that systematically identified, inventoried, mapped, and evaluated remnant natural ecosystems on the east coast of Vancouver Island and the adjacent Gulf Islands.

(HT:ro) or within Wetland Meadows (WN:wm). One of the rarest wetland types, herbaceous wetlands are areas of wet soils and moisture-dependent plants (Ward *et al*. 1998).

Both the HT:ro and the WN:wm units had low representation within the extent of occurrence for *L. pinnatus*. Thirty polygons were mapped as HT:ro units, covering 62 ha and eight polygons were mapped as WN:wm ecosystems across 11 ha. *Lotus pinnatus* was not reported during ground-truthing undertaken at any of the HT:ro and WN:wm ecosystem units. Most of the sites in this area were field-sampled by contracted SEI staff in October. Though seed pods may have been visible at this time of year, the plants are less conspicuous in fruit than when they are flowering. In addition, SEI field surveys were focused on identifying dominant species and percent cover at each site, rather than on rare plant inventory.

Nine HT:ro ecosystem units have been mapped at Woodley Range Ecological Reserve. With the exception of the population observed at the western boundary of the reserve, which was adjacent to SEI polygon # V0165, no further populations of *L. pinnatus* were observed at this location during field work undertaken in 2003.

The absence of data for *L. pinnatus* within the areas identified by the SEI may reflect the small size of the specialized habitats where *L. pinnatus* is found. Although many wetlands smaller than 0.5 ha were mapped by the SEI, the targeted minimum mapping size for most SEI ecosystem types was 0.5 ha (Ward *et al*. 1998). At 500 m^2 (0.05 ha) the area occupied by the largest population of *L. pinnatus* at Harewood Plains North is considerably smaller than the minimum mapping size of the SEI units. The lack of data for *L. pinnatus* within the SEI study area may also reflect the rarity of the specialized habitat required by this species. It is likely that less than 100 ha of suitable habitat exists for *L. pinnatus* in Canada.

The species has not been found to occur on federal lands in the region.

HABITAT

Habitat requirements

General physiography and climate

The British Columbia populations of *L. pinnatus* occur within the Nanaimo Lowlands Ecosection of the Georgia Depression Ecoprovince (Demarchi, 1996). According to the biogeoclimatic ecosystem classification used in the province (Meidinger and Pojar 1991), all known sites occur within the dry maritime (xm) subzone of the Coastal Douglas Fir (CDF) biogeoclimatic zone. In this region, the Olympic Mountains in Washington State to the south and the Insular Mountains on Vancouver Island to the west produce a rain shadow effect resulting in a Mediterranean-type of climate with warm, dry summers and mild, wet winters. Most of the rainfall occurs

during the winter months and limited precipitation and high temperatures during the summer months result in pronounced summer moisture deficits (Meidinger and Pojar 1991). At Nanaimo, annual precipitation ranges from a maximum of 201 mm in December to a minimum of 24 mm in July. The average maximum temperature is 17.6˚ C in August with an average minimum temperature of 2.3˚ C in January (Environment Canada 2003).

Geology and soils

The area around Nanaimo is underlain by a succession of alternating conglomerate, sandstone and shale formations that are often exposed along shorelines and ridge tops (Bickford and Kenyon 1988). Populations of *L. pinnatus* in British Columbia are found in shallow Orthic Dystric Brunisols within the Hiller and Saturna (ST) Soil Associations. These gravelly sandy-loam textured soils have developed on shallow colluvial and morainal deposits overlying an undulating topography of gently sloping sandstone or conglomerate where the bedrock material is frequently exposed near the surface of the soil (Jungen et al. 1985). The soils at all sites are azonal, vary from dark brown to black (organic) and tend to remain moist throughout the late fall to spring, but dry out during the summer. During and shortly after wet periods, water may flow laterally through the saturated subsoil on top of sloping bedrock (Kenney *et al*. 1989.)

Community structure and composition

In British Columbia, *Lotus pinnatus* grows in open, springy meadows, along the margins of creeks, or in seepages, where underground water comes to the surface and the plants are in close physical contact with cool, flowing water (Roemer, pers. comm., 2003). In all cases, the soils are shallow (< 15 cm), over gently sloping sandstone or conglomerate bedrock with abundant moisture during the growing and blooming period.

Lotus pinnatus is most commonly associated with *Mimulus guttatus*, *Plectritis congesta*, *Triteleia hyacinthina*, *Montia parvifolia*, *Plagiobothrys scouleri* (Scouler's popcornflower) and *Veronica beccabunga* ssp. *americana (*American speedwell). Stands of *Pseudotsuga menziesii (*Douglas-fir) and dense thickets of *Rosa nutkana* (Nootka rose)*, Holodiscus discolor* (ocean spray), *Physocarpus capitatus* (nine-bark) and *Salix* spp. (willows) exist on the margin of some seepages but *Lotus pinnatus* does not occur in the shaded understory of these sites, suggesting that the species is shade-intolerant. Prolonged moisture, edge habitat along streams and meadows and shallow soils derived from sedimentary rock are key habitat components. Other factors, such as slope and aspect are variable and do not appear to be critical in defining suitable habitat. In British Columbia, the elevation for this species ranges between 40 m and 150 m.

Populations of *L. pinnatus* appear to be associated with surface or subsurface seepage throughout the species' range. West of the Cascades and along the Columbia River Gorge from northwestern Washington to California, *L. pinnatus* grows from sea

level to higher elevations in the mountains where it is found mostly along slow-moving streams that dry up by mid-summer. In contrast to British Columbia, where the species is found primarily in lowland areas, *L. pinnatus* may be found at elevations of up to 600 m [2000 feet] along the Columbia River from Cape Horn, east to the Klickitat River. *Lotus pinnatus* is well established in the wetland prairie communities that developed in the Willamette and Umpqua valleys and the southern Puget Trough (Guard 1995).

In California, *Lotus pinnatus* occurs in wet meadows, bogs, ditches and stream beds from 600 m to 1700 m, throughout the Klamath Ranges, North Coast Ranges, Cascade Range, northern Sierra Nevada foothills and the Central Coast (Isely 1993). In the United States, *Lotus pinnatus* is federally classified as a facultative wetland species that usually occurs in wetlands (estimated probability of 67% - 99%), but is occasionally found in non-wetlands (USFWS 1988, USDA-NRCS 2002).

Trends

Since there have been no long-term studies of the population dynamics of *Lotus pinnatus* in British Columbia, little information is available on demographic characteristics and population trends. The sprawling habit of the species makes it difficult to identify separate individuals. Previous population estimates by different investigators have varied considerably. Until counting methods are standardized, population numbers should be considered rough estimates.

Populations of aggressive weedy exotic species such as *Anthoxanthum odoratum*, *Bromus sterilis* and *Cytisus scoparius* have become established at all sites and may threaten the long term ecological integrity of each population.

Although *L. pinnatus* appears to be relatively secure within Oregon, Washington and California, the status of its critical habitat in Idaho has not been assessed (Mancuso, pers. com., 2003.)

In Oregon and Washington*, Lotus pinnatus* occurs within the wetland prairie communities that developed in the Willamette and Umpqua valleys and the southern Puget Trough. Although these moist prairie grasslands once covered extensive areas of the Willamette Valley, only 0.2% of the wetland prairie that existed in 1850 is still present (Guard 1995).

Protection/ownership

With the exception of the occurrence at the Woodley Range Ecological Reserve, established in 1996, all extant populations of *Lotus pinnatus* in Canada lack legal habitat protection on privately owned land. Despite efforts to restrict entry to recreational off-road vehicles at Harewood Plains, local residents report that off-road vehicle use has increased in recent years (Thurkill pers. com. 2003)). In areas with heavy off-road vehicle use, the fragile, shallow soils have been damaged and eroded, exposing the bedrock below.

The population of *L. pinnatus* at Woodley Range lies near (within 20 m of) the boundary of the Ecological Reserve. Plants within the Ecological Reserve are protected to some extent under the *Protected Areas of British Columbia Act*, and a valid park use permit is required before a plant can be destroyed, damaged or disturbed. However, the protection afforded by this legislation is unlikely to protect the population from habitat threats because there is little monitoring or enforcement of the Act. Terrestrial herbaceous ecosystems are vulnerable to adjacent land uses and disturbance from logging and other land clearing activities provide an opportunity for the introduction of aggressive alien plant species, which can then spread into the adjacent sensitive ecosystem (Ward *et al*.1998).

BIOLOGY

General

Lotus pinnatus is a monoclinous (having the stamens and pistils in the same flower), perennial plant, flowering from May to July, and withering over the winter months (Hitchcock et al. 1961). Though little information regarding breeding systems and pollination biology is available on *Lotus pinnatus* specifically, some of the information about the genus in general may apply to this species.

Zandstra and Grant (1968) studied the biosystematics of native and introduced *Lotus* species in Canada and reported that although many of the Old World species are polyploids, none of the North American species examined exhibited the same trait. North American *Lotus* species have a base chromosome number of 6 or 7. Of the species native to Canada*, L. pinnatus* Hook. and *L. formosissimus* are considered to be the most closely related, based on morphological, habitat, and cytological characteristics. A chemotaxonomic study using thin-layer chromatography further supported the general relationships among Canadian *Lotus* species with *L. formosissimus* and *L. pinnatus* demonstrating the greatest degree of similarity (Grant and Zandstra 1968). These species differed from other native Canadian species in that both were perennial outcrossers with large flowers on long pedunculate umbels. The other three native species were self-fertile annuals with small flowers. Evolution in angiosperm reproduction has frequently occurred with a decrease in basic chromosome number, a shift from an outcrossing (cross-pollinating) to an inbreeding (self-pollinating) reproductive system and a shift from a perennial to an annual habit (Stebbins, 1957). On this basis, Zandstra and Grant (1968) considered *L. pinnatus* and *L. formosissimus* to be more primitive than the annual species.

Lotus pinnatus germinates and begins growth in late winter – early spring as a result of increasing daylength and the warm, moist conditions found at this time of the year. Since the surrounding vegetation, especially grasses, are shorter during this period, the herbs also benefit from greater light levels and space to grow. There is no specific information on the effect of photoperiod on *L. pinnatus,* but *L. corniculatus* has been reported to require a minimum daylength of 14.0 to 14.5 h for flowering (Joff 1958, McKee 1963). Vegetative growth in *L. pinnatus* occurs in early spring and each plant

sends up 3 to 6 shoots from its taproot, on average. Though the specific timing of events will depend on local habitat conditions and may vary from year to year, flowering in *L. pinnatus* generally occurs between May and the end of June. The pea-like, bisexual flowers are borne at the end of a long peduncle arising from the leaf axil, and the umbellate inflorescences are produced sequentially throughout the growing season. As the flowers senesce, some become progressively more reddish (Isely 1981). Fruiting begins before summer moisture deficits reduce the plant's productivity. Each ramet is likely to have flower buds, flowers, and immature fruits in various stages of development, at any time during the growing season. During July, when drought conditions are prevalent, seed maturation and dispersal begins, followed by die-back of the stems to the rootstock, which is located several centimetres below the soil surface. The plants become senescent and remain dormant until the following year.

Young and Young (1986) reported that seeds of many native North Amercian *Lotus* species are deeply dormant, with multiple forms of complex dormancy, and require pre-treatment to induce germination. Although a hot water treatment may be used to enhance germination, high germination rates are not expected with this technique (Young and Young 1986). Like other members of the Fabaceae, the seeds of *L. pinnatus* have a hard seed coat and may require cold stratification as germination occurs mainly in the spring. Although the specific germination requirements of *L. pinnatus* have not been documented in the literature, Hitchcock *et al*. (1961) indicated that the three perennial species, *Lotus pinnatus, L. crassifolius* and *L. formosissumus,* were easily grown from seed. Zandstra and Grant (1968) reported that they grew *L. pinnatus* from seed to provide live material for their investigations, although the cultivation methods were not described.

Seeds of *Lotus pinnatus*, collected from Harewood Plains were used in an applied research program initiated in 1996 to determine the utility of native Vancouver Island grasses and legumes in the restoration of disturbed areas. About 80-90% of untreated seed sown in 1998 at a Seed Increase Nursery in Duncan, B.C., and left to over winter in the greenhouse, germinated early the next spring. Approximately 60 emergent seedlings were transplanted to a test plot during moist conditions in April, 1999. As of July 2003, only 10 plants have survived. Although the addition of legumes to seeding mixtures has the potential to improve soils through fixation of nitrogen, continuous flowering and pod shattering in *Lotus pinnatus* renders mechanical seed harvesting impractical. *Lotus pinnatus* was eliminated as a realistic reclamation candidate from a large-scale seeding perspective, as the costs currently associated with production exceed fair market value (Vaartnou, pers. com., 2003).

The tendency of seed pods to shatter is common to all known varieties of *L. corniculatus*, and is responsible for substantial seed losses in this widely grown forage crop. Though efforts to reduce shattering through recurrent selection have been unsuccessful, attempts to transfer the indehiscent trait from related indehiscent species via interspecific hybridization and by interspecific somatic hybridization, have shown some promise (Grant 1996, 1999).

A review of the literature indicates that no morphological comparisons or DNA studies have been conducted to address the issue of whether *L. pinnatus* populations in British Columbia are distinct from those in the southern part of its distribution.

Reproduction

Like other perennial species in genus *Lotus*, Zandstra and Grant (1968) suggested that the flowers of *Lotus pinnatus* required cross-pollination to set viable seed. MacDonald (1944) showed that twice as many flowers of *L. corniculatus* were fertilized with pollen from other plants of the same species as with pollen of the same plant. When pollinators were excluded, no fertilized ovules were produced. Though specific pollinators have not yet been reported in the literature for *L. pinnatus*, honey bees (*Apis melifera*), bumblebees (*Bombus* spp.) (Jones *et al*. 1986) and leaf-cutting bees (*Megachile rotundata*) have been described as effective pollinators of the related perennial species, *L. corniculatus* (Beuselinck and McGraw 1988). It is not clear how frequently pollen is exchanged in *Lotus pinnatus* and over what distances but Morse (1958) reported that 12 to 15 visits per flower were required for maximum seed set in *L. corniculatus*.

The *Lotus* flower is constructed so that the anthers of the longer fused stamens are enclosed within the beak of the keel petals. Pollen is released into the beak of the keel petals prior to flowering. Pressure exerted by visiting insects on the keel causes the five dilated staminal filaments to act as a piston, pushing pollen out of the tip onto the ventral surface of the insect's thorax (Kirkbride 1999). In *L. corniculatus*, the protrusion of the pistil beyond the stamens places the pistil in closer contact with pollen deposited on the body of visiting insects than with the pollen of its own flower and is believed to be an adaptation to ensure cross-pollination (Morse 1958).

Given the bright yellow appearance of the flower and the wide keel that serves as a suitable landing platform, flowers of *L. pinnatus* also appear to be adapted to bee pollination. Although the importance of the bumblebee to the flower (and vice versa) is yet to be specifically determined, bumblebees were observed visiting flowers of *L. pinnatus* at Harewood Plains during field observations made in 2003 (personal observation). Although bees are capable of dispersing pollen over short distances, cross-pollination between most populations in Canada is unlikely in view of the distances involved.

Asexual reproduction has not been studied in *L. pinnatus*, but shoots of *L. corniculatus* have been successfully regenerated from callus or suspension cultures derived from leaves, cotyledons, hypocotyls and roots. Excised root segments cultured on a hormone-free medium also gave rise to shoots with high frequency (Morris *et al*. 1999).

Survival

There is no documentation of the average life span of an individual genet and survivorship curves have not been developed for this species, but *L. pinnatus* is a perennial species that may survive for several years, under favorable conditions. The species germinates in the late winter or early spring when soil moisture and temperature conditions are most favorable and seedling survival appears to be dependent on continuous surface moisture. Established populations of *L. pinnatus*, at most sites, consist of both perennial plants and first year seedlings (personal observation 2003).

Field observations at all sites during in 2003 did not reveal any significant cases of adult mortality from natural causes; however, a patch of plants in a small wetland area at Harewood Plains had been crushed by off-road vehicles entering the wetland and in some areas the soil has been rutted down to the bedrock. This particular wetland is heavily used by off-road vehicles and anecdotal reports suggest that the population of *L. pinnatus* has declined from about 500 individuals observed in previous years to only 40 plants observed in 2003 (Thurkill pers. com., 2003).

Movements/dispersal

The fruits (pods) of *L. pinnatus* are linear legumes, 3–6 cm in length, derived from a superior ovary, which holds a single carpel. Development of the pod is accompanied by progressive changes in color from a waxy dark green to deep brown (Isely, 1981). In *L. corniculatus*, the pods mature in approximately three weeks. At maturity, the two valves of the pod twist spirally in a quick snapping motion and the seed is ejected when the pod dehisces along the ventral and dorsal sutures of the carpel margins (Grant 1996).

The glabrous, dark brown seeds in *L. pinnatus* are oval to spherical and number approximately 332 per gram (Piggott, pers. com., 2003). In an examination of ten pods, the average number of seeds per pod was ten (personal observation 2003).

The seeds lack any strong adaptations for long-distance dispersal by wind or animal vectors. Most seeds are gravity-dispersed and generally land in the immediate vicinity of the parent plant. The plant's habitat along stream channels may permit the legumes and seeds to be transferred by water during times of seasonal flooding. However, germination and seedling survival appear to depend upon continuous surface moisture and the species does not appear to be a strong competitor with native shrub species or with invasive exotic plants. The chances of a healthy population returning to Canada if local populations become extirpated are highly unlikely. The nearest population in Washington State, from which collections were made in 1940, is 240 km away in Bremerton. Whether this population is extant is unknown.

Nutrition and interspecific interactions

Like many other legumes, *L. pinnatus* appears to be associated with nitrogen-fixing *Rhizobium* bacteria that occupy root nodules and provide the plants with a source of

reduced nitrogen in exchange for a supply of carbon and other nutrients. *S*pecific strains of *Rhizobium* bacteria are required for effective nodulation of *Lotus* species grown as forage crops, such as *L. corniculatus* and *L. tenuis.* To maximize establishment in areas that have never produced *Lotus*, inoculation of seeds with the appropriate rhizobia is necessary (Blumenthal and McGraw 1999).

An examination of root nodules collected from *L. pinnatus* at Harewood Plains indicated the presence of bacteria, most likely of genus *Rhizobium* (Berch pers. com., 2003).

Cyanogenic glucosides are chemical compounds that are widely distributed in legumes. These compounds release hydrogen cyanide (HCN) if the leaf tissues are damaged and are presumed to be a deterrent against herbivory, though many animals possess the ability to detoxify cyanide (Vetter 2000). Though cyanogenic glucosides are commonly found in Old World *Lotus* species, Grant and Sidhu (1967) found the reverse to be true for North American species. Of the fifteen *Lotus pinnatus* plants that were tested for the presence of hydrogen cyanide, all were negative.

Behaviour/adaptability

At Harewood Plains, small plants have been observed growing in the moisture retained in tire ruts, suggesting that this species can tolerate some disturbance, provided subsurface drainage and other critical factors are not altered. However, the thin soils where *L. pinnatus* grows take a long time to form and are highly sensitive to disturbance. All-terrain vehicle use is inappropriate in these habitats as they damage fragile soils and vegetation (McPhee *et al*. 2000). As *Lotus pinnatus* does not appear to be a strong competitor, ecological succession following disturbance and invasion by non-native species has the potential to alter the structure and composition of habitats occupied by *Lotus pinnatus*, possibly preventing their re-establishment.

POPULATION SIZES AND TRENDS

General

Lotus pinnatus has been reported from nine sites in British Columbia (Table 1), all in the Nanaimo area on Vancouver Island and on Gabriola Island, nearby. Of the nine reported records, seven populations were verified during this study. The remaining two sites have been extensively disturbed and it is unlikely that these populations currently exist. Between 1500 and 2000 individual plants were counted in Canada in 2003 over an area of 650 m^2.

Relatively little is known of demographic characteristics and population trends of *L. pinnatus* due to a lack of long-term monitoring, though the number of individual plants appears to have increased at one site, on Gabriola Island.

Table 1. Populations of *Lotus pinnatus* in British Columbia.

Populations	Observation Date	Collector/Observer	Number of Individual plants	Apparent Status
No. 1 Harewood Plains North[3]	2003-06-07	M. Donovan	1500 in 500 m^2	Extant
No. 2 Harewood Plains South 1	2003-07-12	M. Donovan	25 in 4 m^2	Extant
No. 3 Harewood Plains South 2	2003-07-12	M. Donovan	10 in 2 m^2	Extant
No. 4 Woodley Range	2003-06-01	M. Donovan	120 -140 in 90 m^2	Extant
No. 5 Gabriola Island, off Peterson Rd., on Perry Rd.	2003-05-25	Donovan/Penny	65 -70 in 10.5 m^2	Extant
No. 6 Nanaimo, west of Cinnabar Valley	2003-06-15	M. Donovan	40 in 25 m^2	Extant
No. 7 Nanaimo, south of Extension	2003-06-23	M. Donovan	30 to 45 in 17 m^2	Extant, but declining
No. 8 Waddington & Departure Bay Roads Nanaimo	1939-06-02	J.W. Eastham	N/A	Extirpated
No. 9 Departure Bay Rd. and Island Hwy, Nanaimo	1965-06-20	K. Beamish	N/A	Extirpated

Estimates of population trends in *L. pinnatus* are currently unreliable as the clumped, sprawling habit makes it difficult to identify separate individuals and counting methods have varied with different investigators. Until counting methods are standardized, population numbers should be considered rough estimates. On average, each individual (genet) includes from 3 to 5 shoots.

The inventory for the purposes of this report involved a count of all stems at each site. Each site was surveyed by walking a series of transects and counting individual stems. It was highly impractical to count each individual stem at the Harewood Plains site due to the large number of stems involved, and because they were spread over a large area. Therefore, a grouping method was used to simplify counting at this site. A group of ten, or in some cases fifty, stems were clustered together to gain a visual picture of the area occupied by the stems. The site was then surveyed by walking a series of transects and stems were counted based on the grouping method.

[3]The collection by W.R. Carter at Mt. Benson in 1918-06-01 is included with this population as Harewood Plains may be considered the foothills of Mt. Benson.

The disappearance of the populations at Departure Bay in Nanaimo has resulted in a decline of 15% in the extent of occurrence for this species, from an area of 118 km^2 in 1939 (assuming that all currently extant populations also existed at that time) to 100 km^2 in 2003. As the British Columbia population is geographically isolated from the nearest reported Washington site (for which the current status is unknown) by approximately 240 kilometres, the chances of a healthy population returning to Canada if local populations become extirpated are highly unlikely.

Harewood Plains, S of Nanaimo

The population of *L. pinnatus* at Harewood Plains occurs in three discrete areas. They are best treated as separate populations because they are well separated and the intervening terrain is not conducive to pollen and seed dispersal. The majority of plants (approx. 22 subpopulations) are located at the north end of the site; two small populations occur in open meadows further south. In 2003, a total of about 1500 individual plants were observed at these three sites. This estimate includes three previously undocumented patches. If each individual plant includes an average of four shoots per clump, any change in the number of plants from estimates reported in 1998 is likely to be smaller than the errors in counting, associated with the method of enumeration.

The bedrock at this location, which belongs to the “Millstream Member” of the Extension Formation (Bickford and Kenyon, 1988), consists of thick-bedded pebble-conglomerate, with interbeds of coarse-grained, gritty sandstone (Bickford 1993).

Lotus pinnatus grows in dense clusters in vernal seepages at this site, often at the margins of moist thickets populated by *Rosa nutkana, Physocarpus capitatus, Holodiscus discolor* and *Salix* spp. The two most northern subpopulations, overlooking the parkway, occur in scattered openings within a *Pseudotsuga menziesii/Arbutus menziesii* (Douglas-fir/arbutus) plant community. Plants were also observed growing along the sides of tire ruts where moisture is retained for prolonged periods. The most common associated species at this location include *Mimulus guttatus, Triteleia hyacinthina, Plectritis congestus, Plagiobothrys scouleri, Veronica beccabunga* ssp. *americana and Montia parvifolia*. Overall, the vigour of most sub-populations appears to be good, although two populations have declined in areas where the soil has been eroded from off-road vehicle use and *Anthoxanthum odoratum* dominates adjacent grassy meadows. Morphological differences such as the number of flowers per inflorescence are evident among subpopulations at this location indicating the existence of genetic variation and outcrossing.

Three other plant species known from this locality are rare in British Columbia (Douglas *et al*. 2002). *Epilobium densiflorum* and *Carex feta* appear on the provincial Red list maintained by the British Columbia Conservation Data Centre. *Allium amplectens* is on the provincial Blue list.

Woodley Range Ecological Reserve

Within 20 m of the western boundary of Woodley Range Ecological Reserve, *Lotus pinnatus* was observed growing in shallow water along a small outlet stream connecting two wetlands. In 2003, 120-140 individual plants were observed growing in two sub-populations of 5 m^2 and 30 m^2. Soils at the site were moist, shallow and with frequent sandstone outcrops. Native species associated with *L. pinnatus* included *Rosa nutkana, Spirea douglasii, Holodiscus discolor, Plectritis congesta, Mimulus guttatus, Montia parvifolia and Philonotis fontana. Anthoxanthum odoratum and Cytisus scoparius* were also present. Two red-listed plants, *Seriocarpus rigidus* and *Carex feta* and two blue-listed plants *Allium amplectans* and *Isoetes nuttallii* have also been reported from within the Woodley Range Ecological Reserve. A red-listed *Alnus rubra/Carex obnupta* [*Populus balsamifera* ssp*. trichocarpa*] plant community has been identified at the fen/swamp wetland drained by the creek where *L. pinnatus* is found. The number of plants at Woodley Range Ecological Reserve (ER) was not reported in 1992, precluding a comparison with plants observed in 2003. The area occupied by the population at Woodley Range ER appears to be unchanged since 1992.

Gabriola Island

Lotus pinnatus was found growing along both sides of an inundated ditch at the edge of a moist thicket on Perry Road. Associated species include *Craetagus douglasii* (black hawthorn)*, Holodiscus discolor, Spirea douglasii, Oenanthe sarmentosa, Rosa nutkana* and *Vicia sativa*. Also present at the site were *Anthoxanthum odoratum*, *Plantago lanceolata*, *Galium aparine* and *Ranunculus flammula*. The soil at this site is a shallow Orthic Dystric Brunisol within the Saturna (ST) Soil Association on top of sandstone bedrock (frequently exposed throughout the island). This population appears to have increased from a single plant observed in 1996 to about 65-70 in 2003, over an area of 10.5 m^2. Although the plant has spread to occupy suitable habitat along the ditch, there is no assurance of protection from development for this privately owned property.

Nanaimo, west of Cinnabar Valley

This site is located on private property, south of Nanaimo, west of White Rapids Road. In 2003, about 40 flowering plants were counted over an area of 25 m^2, in a vernal seepage located in a grassy meadow at the edge of *Pseudotsuga menziesii* forest with *Rosa nutkana, Holdiscus discolor, Montia parvifolia, Plectritis congestus, Mimulus guttatus* and *Camassia quamas*. *Anthoxanthum odoratum* and *Holcus lanatus* have also become established at this site. The population of *L. pinnatus* west of Cinnabar Valley appears to have experienced no significant change in numbers since 1998. As the property is privately owned and frequently used by paintball teams, surveys conducted in 2003 may have been incomplete and it is possible that additional patches of *L. pinnatus* may occur in forest openings at this location.

Nanaimo, south of Extension

This site is located on private property, south of Nanaimo. In 2003, ten plants were observed over 5 m^2, growing in a vernally moist area on the margin of a *Physocarpus captitatus* thicket with *Mimulus guttatus, Allium cernuum, Montia parvifolia* and *Anthoxanthum odoratum*. A second population of 20-35 plants was found in a vernally wet seep in an open meadow at the edge of a *Malus fusca* (crab apple) thicket with *Mimulus guttatus, Allium cernuum* and *Anthoxanthum odoratum*. Four other rare plants have been reported at this location. These include the red-listed species *Epilobium densiflorum* and *Carex feta* and the blue-listed species *Cyperus squarrosus* and *Botrychium simplex*. In 2003, only 50% of the plants reported in 1995 were observed at this site, despite detailed searches of the most suitable habitat. Recreational use of this site by off-road vehicles during the wet season may be responsible for the apparent decline.

Extirpated populations

Waddington & Departure Bay Roads (Nanaimo)

Lotus pinnatus was collected at this site in 1939 by J.W. Eastham. Since 1951, the roads in the area have been widened and resurfaced to accommodate the increased development that has taken place. Almost all of the natural vegetation has been eliminated. Given the extent to which this area has been altered and the length of time since *L. pinnatus* was last observed, it is very unlikely that *L. pinnatus* is extant at this site.

Departure Bay Rd. and Island Hwy, (Nanaimo)

Lotus pinnatus was collected at this location in 1965 by K. Beamish. Presently, this area is dominated by shopping plazas and highways. Little of the existing vegetation remains in the ditch along Departure Bay Road where almost all of the native vegetation has been replaced by introduced and horticultural species. It is very improbable that *L. pinnatus* is extant at this locality.

Status Unknown

There is a herbarium record, dated 1918, indicating an observation made in the “foothills” at “Mount Benson”. Since Mount Benson is visible from Harewood Plains, it is possible that this historic record is referring to the sites described for Harewood Plains. According to anecdotal reports from a local naturalist who hikes Mount Benson regularly, *Lotus pinnatus* has not been observed growing at higher elevations at this location (Thurkill pers. com., 2003).

LIMITING FACTORS AND THREATS

Habitat loss presents a serious and urgent threat to *Lotus pinnatus* in Canada. Harewood Plains is currently under application for a development permit for a trailer park. This site contains the only large population of *L. pinnatus* in Canada and approximately 25 - 30% of the plants at this location are at risk. The landowner has applied for a Preliminary Layout Agreement and the City of Nanaimo has requested an environmental inventory of the property (Lawrance pers. com., 2003). The existence of rare species may be easily overlooked unless the vegetation inventory is conducted during the appropriate season when plants are visible.

The population of *L. pinnatus* at Harewood Plains is also under direct and immediate threat of habitat degradation resulting from intensive use of recreational off-road vehicles. Although this species appears to tolerate some disturbance, the shallow soils at Harewood Plains and at site 7 (Nanaimo south of Extension) are vulnerable to degradation by current recreational uses. In some areas at Harewood Plains, the thin and fragile soils have been rutted to bedrock and plants have been dislodged on to bare rock where they cannot re-establish (Figure 4). There is high potential for further impacts.

Root systems may be damaged or destroyed through compaction. Hydrological disruptions that modify groundwater flow also constitute a threat to this species' long-term survival. Vehicles continue to access the site on a regular basis, despite efforts to restrict access to off-road vehicles by the installation of several cement barriers along the access road (Thurkill pers. com., 2003).

Recreational use of off-road vehicles creates ample dust that covers the flowers and hinders pollination and at Harewood Plains has also resulted in the fragmentation of essential habitat. In areas where the vehicles enter the seepages, plants have been damaged and populations have become partitioned. Once a previously contiguous population becomes segregated into a series of isolated smaller patches the smaller populations may no longer interbreed, resulting in restricted gene flow and reduced genetic variability. The ability of species to colonize available habitat is also reduced (McPhee et al. 2002). Information is not available on the number of plants required to maintain viable populations of *L. pinnatus*; however, an effective population size of about 5,000 individuals is considered necessary to maintain sufficient adaptive genetic variability for evolution to occur (Culotta 1995, Lande 1995). Populations that fall below 1000 individuals will experience the accumulation of deleterious alleles that may ultimately result in further population declines and extirpation. Therefore, to maximize genetic and ecological variation and prevent the consequences of small population size, the effective population size needs to be at least 5000 individuals (Culotta 1995, Lande 1995).

Figure 4. Destruction of habitat caused by all-terrain vehicles at Harewood Plains (photo courtesy, G.W. Douglas, June 29, 2003).

Over 99% of the extant population of *L. pinnatus* is located on land that is privately owned, making this species vulnerable to habitat loss as a result of urban expansion and residential development. The population of the Regional District of Nanaimo increased from 77,624 residents in 1981 to 127,016 residents in 2001, and is projected to increase to 219,321 residents by 2026 representing an average growth rate of approximately 2.9% per year and a total increase of 73% over 1981 to 2026 (BC Statistics, 2003).

The real estate market within the Regional District of Nanaimo saw above-average growth during 2002 - 2003, due to low mortgage rates and consumer confidence in the prospects of the provincial economy. According to the Canada Mortgage and Housing Corporation (2003), housing starts in Nanaimo were 57.7% higher in the first quarter of 2003, compared to the first quarter in 2002. The momentum of starts is expected to continue through 2003 as low housing inventories in British Columbia and strong consumer demand continue to support sales activity (CMHC 2003). Despite the rocky terrain, Harewood Plains has high potential for residential development due to the broad panoramas provided of the surrounding landscape.

Other than habitat destruction, competitive exclusion from native and non-native vegetation represents the most significant ongoing threat to *L. pinnatus* at all sites. Encroachment of native shrub species in potential habitats may prevent this species from occupying new sites. Severely invasive alien grass species that threaten the persistence of *L. pinnatus* include *Anthoxanthum odoratum, Dactylis glomerata*, *Poa pratensis* and *Bromus sterilis*. *Cytisus scoparius* is the most dominant exotic herbaceous shrub. By aggressively sequestering water and nutrients and reducing light at ground level, many alien species can outcompete native species, reducing their

ability to maintain themselves within open meadow sites. As invasive species become more dominant they have the potential to modify ecosystem processes by producing extensive, nitrogen-enhanced litter, by altering fire regimes as a result of their high flammability and by exacerbating soil moisture deficits (D'Antonio and Vitousek 1992).

Logging operations close to (within 50 m of) populations of *L. pinnatus* at Harewood Plains increase the potential for the spread of aggressive native and non-native plant species. Invading Douglas-fir trees have become established in the vicinity of several subpopulations of *L. pinnatus* at Harewood Plains, likely as a result of fire suppression. If permitted to grow, these trees could alter the composition of the grassland meadow complex by reducing the amount of open habitat available for *L. pinnatus* and other less shade-tolerant species. Logging prescriptions or other future management activities that would result in direct sunlight and rapid evaporation in occupied habitat for extended periods may pose a threat to populations of this species. Off-road vehicles are also a major factor in the spread of invasive non-native plants in sensitive areas. Off-road vehicles make it easier for exotic plants to become established, by disturbing soils and carrying seeds. A Montana study showed that a single off-road vehicle can spread 2000 knapweed seeds over a 16 km [10 mile] area during one trip. (Lacey *et al*. 1997).

The specific habitat requirements of *L. pinnatus*, though not definitively known, clearly indicate the relatively restrictive conditions for the establishment, growth and dispersal of this species. The localized nature of available habitat is thus a strong limiting factor within the currently known range of *Lotus pinnatus*.

SPECIAL SIGNIFICANCE OF THE SPECIES

Lotus pinnatus is not known to be currently collected for any purpose in Canada. Seed can be purchased online from an American seed company (Fraser pers. com. 2003), presumably for horticultural use or for the restoration of disturbed sites. The species could also be tested for medicinal compounds. In southern California, the Kumeyaay Indians used a decoction of *Lotus scoparius* (common deerweed) leaves to treat coughs. The foliage of this species was fed to domesticated animals and was used with dry pine needles to line pits for roasting yucca. *Lotus scoparius* was also used by the Kumeyaay as a construction material to thatch houses (Southwest Centre for Environmental Research and Policy 2003). Guard (1995) reported that the seeds and foliage of *L. pinnatus* provide food for a variety of wildlife species and that the seeds are especially important to quail and small mammals.

The British Columbia populations of *L. pinnatus* are at the northern extent of the geographic range of the species. Isolated peripheral populations are often genetically and morphologically divergent from central populations. The ability of a species to adapt to changing ecological conditions and therefore, its long-term survival, may rest on the conservation of these genetically distinct peripheral populations (Lesica and Allendorf 1995).

As they form an interconnected series of subpopulations that can interbreed and form the central core of the species' range in British Columbia, the populations of *Lotus pinnatus* at Harewood Plains are especially significant and worthy of conservation. An improved understanding of the ecological needs of individual rare species is necessary to ensure that introduced populations can persist. The protection of larger populations throughout the species' range is necessary for maintaining genetic diversity and long-term persistence. Large populations also serve as seed sources for dispersal into available habitat.

The grassland meadow ecosystems in which *L. pinnatus* is found are unique. They have developed under a soil moisture regime found nowhere else in Canada and support a unique assemblage of plants, several of which have become rare. Grassland meadow complexes, and the indigenous species associated with them, have been extirpated from much of their historic range throughout western North America (Guard 1995).

EXISTING PROTECTION OR OTHER STATUS DESIGNATIONS

NatureServe (2002) has assigned a global rank of G4G5 for this species. This ranking indicates that, on a global scale, the plant is considered to be "apparently secure, but may have restricted range or possible long-term concerns".

In British Columbia, the British Columbia Conservation Data Centre in the Ministry of Sustainable Resource Management has ranked *L. pinnatus* as "S1" and placed it on the "Red list". A provincial rank of "S1" indicates that the species is "critically imperiled because of extreme rarity (5 or fewer extant occurrences or very few remaining individuals) or because of some factor(s) making it especially vulnerable to extirpation or extinction". This is the most critical status that can be applied to a species at the provincial level.

Currently no specific legislation protects rare and endangered vascular plants in British Columbia. While the population of *L. pinnatus* located in the Woodley Range Ecological Reserve is protected, to a certain extent, by its location within an ecological reserve, only 7% of the total Canadian population is present at this site. Plants at this location are vulnerable to adjacent land uses including all-terrain vehicle use, logging and other land clearing activities. Logging operations adjacent to the core population increase the potential for colonization by aggressive invasive plant species that can then spread into the adjacent ecological reserve. The extant populations of *L. pinnatus* on private property at Harewood Plains are also vulnerable to habitat destruction from commercial development and intensive use by off-road vehicles.

In California, *L. pinnatus* has been assigned a subnational rank of "S?" indicating that the rank has not been assessed, presumably due to its apparent large distribution (Bittman pers. com. 2003). In Washington, Oregon and Idaho, the species has a subnational rank of 'SR'. This designation is intended to indicate that the species is

“reported for the state, but without persuasive evidence for either accepting or rejecting the report”. However, the existence of verified collections with precise location data invalidates this rank. In Oregon, it appears that the plant should be more properly ranked S3S5 based on information provided by Natural Heritage Program Botanist, Sue Vrilikas (Vrilikas, pers. com. 2003). There is insufficient information available to determine the true status of this plant in Washington State. In Idaho, the plant should be ranked S1 based on the single collection specimen available (Mancuso, pers. comm. 2003).

TECHNICAL SUMMARY

Lotus pinnatus
bog birds-foot trefoil lotier à feuilles pennées
Range of Occurrence in Canada: British Columbia

Extent and Area Information	
• *Extent of occurrence (EO)(km²)* **(Polygon encompassing all known sites)**	100 km²
• *Specify trend in EO*	decline
• *Are there extreme fluctuations in EO?*	no
• *Area of occupancy (AO) (km²)* **(Area occupied by plants)**	<<1 km² (<0.06 ha)
• *Specify trend in AO*	decline
• *Are there extreme fluctuations in AO?*	no
• *Number of known or inferred current locations*	7 populations
• *Specify trend in #*	historic decline
• *Are there extreme fluctuations in number of locations?*	no
• *Specify trend in area, extent or quality of habitat*	declining
Population Information	
• *Generation time (average age of parents in the population)*	several years (3-5 years?)
• *Number of mature individuals*	1500-2000
• *Total population trend:*	declining (largest population will be significantly reduced if proposed development proceeds)
• *% decline over the last/next 10 years or 3 generations.*	possibly 25% loss inferred if development proceeds
• *Are there extreme fluctuations in number of mature individuals?*	no
• *Is the total population severely fragmented?*	yes
• *Specify trend in number of populations*	decline
• *Are there extreme fluctuations in number of populations?*	no
• List populations with number of mature individuals in each: 1. Harewood Plains North: 1500 2. Harewood Plains South 1: 25 3. Harewood Plains South 2: 10 4. Woodley Range: 120-140 5. Gabriola Island: 65-70 6. Nanaimo, west of Cinnabar Valley: 40 7. Nanaimo, south of Extension: 30-45	
Threats (actual or imminent threats to populations or habitats)	
- loss, degradation and fragmentation of habitat from proposed development and recreational use of all-terrain vehicles; invasive species	
Rescue Effect (immigration from an outside source)	
• *Status of outside population(s)?* **USA:** Stable in some jurisdictions, uncertain in others	
• *Is immigration known or possible?*	unlikely
• *Would immigrants be adapted to survive in Canada?*	unknown
• *Is there sufficient habitat for immigrants in Canada?*	uncertain
• *Is rescue from outside populations likely?*	unlikely

Quantitative Analysis	Not Applicable
Other Status	

Status and Reasons for Designation

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

Reasons for Designation:
Few small fragmented populations that are geographically restricted and found within wetland meadows of limited occurrence and considerably disjunct from the main range of the species in the northwestern United States. Populations are at risk from continued habitat loss and encroachment of invasive species and from recreational off-road vehicular activities with the likelihood of significant losses due to planned commercial development of habitat supporting the only sizeable remaining population.

Applicability of Criteria

Criterion A (Declining Total Population): Not Applicable

Criterion B (Small Distribution, and Decline or Fluctuation): Endangered due to small distribution and decline under B1 and B2 (a) +(b, ii, iii, v) with EO about 100 km^2 and AO <1ha and highly fragmented localities with continuing decline anticipated in area of occupancy, area and quality of habitat and number of mature individuals.

Criterion C (Small Total Population Size and Decline): Endangered under C1 as a consequence of a small total population of 1500-2000 plants with continuing decline projected of about 25% if development of major site proceeds.

Criterion D (Very Small Population or Restricted Distribution): Threatened under D2 due to the species' small AO <20 km^2 and only 7 localities

Criterion E (Quantitative Analysis): Not Applicable.

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LITERATURE CITED

Abrams, L. 1944. *Hosackia, Lotus*. An illustrated flora of the Pacific States. Vol. 2. Stanford Univ. Press, Stanford, CA.

Allen, W.H. 1994. Reintroduction of endangered plants. Bioscience 44:65-86.

Arambarri, A.M. 1999. Illustrated Catalogue of *Lotus* L. Seeds (Fabaceae). Pp. 43-60 *in* P.R. Beuselinck, ed., Birdsfoot Trefoil: The Science and Technology of *Lotus*. American Society of Agronomy.

Bentham, G, 1929. *Hosackia bicolor*, two-coloured *Hosackia*. Edward's Botanical Register 15:7/1257 and associated text. Lovell Reeve & Co., London.

Beuselink, P.R., and R.L. McGraw. 1988. Indeterminate flowering and reproductive success in birds-foot trefoil. Crop Sci. 28:842-845.

Bickford, C.G.C. and C.E. Kenyon. 1988: Coalfield geology of eastern Vancouver Island (92F). Pp. 441-450 *in* Geological Fieldwork, 1987, British Columbia Ministry of Energy, Mines and Petroleum Resources, Victoria, BC.

Bickford, C.G.C. 1993. Geology and Petrography of the Wellington Seam, Nanaimo Coalfield, Vancouver Island. M.Sc. thesis. University of British Columbia, Vancouver, BC.

Blumenthal, M.J., and R.L. McGraw. 1999. *Lotus* adaptation, use and management. Pp. 97–119 in P.R. Beuselinck, (ed.) Trefoil: The science and technology of *Lotus*. Crop Science Society and the American Society of Agronomy. Madison, WI.

Brand, A. 1898. Monographie der Gattung *Lotus*. Bot. Jahrb. Syst. 25:166-232.

British Columbia Statistics Population Section, Ministry of Management Services, Government of British Columbia. Web site: http://www.bcstats.gov.bc.ca/data/pop/pop/popproj.htm [Accessed: July 6, 2003].

CalFlora. Information on California plants for education, research and conservation. [web application]. 2003. Berkeley, California: The CalFlora Database [a non-profit organization]. Web site: http://www.calflora.org/. [Accessed: Jul 12, 2003].

Callen, E.O. 1959. Studies in the genus *Lotus* (Leguminosae). I. Limits and subdivisions of the genus. Canadian Journal of Botany 37:157-165.

Camarario, A.J. 1588. *Hortus Medicus et Philosophicus*. Frankfurt, Germany.

Canada Mortgage and Housing Corporation (CMHC). First Quarter 2003. Market Insight. Web site: http://www.vancouverbcrealty.com/specialreports/housingtrends.pdf. [Accessed: August 1, 2003].

Cullota, E. 1995. Minimum population grows larger. Science 270:32-32.

D'Antonio, C.M and P.M. Vitousek. 1992. Biological invasions by exotic grasses, the grass/fire cycle, and global change. Annu. Rev. Ecol. Syst. 23:63-87.

Demarchi, D.A. 1996. Ecoregions of British Colubmia. Wildlife Branch, Ministry of Environment, Lands and Parks, Victoria, BC.

Douglas, G.W., D. Meidinger and J. Pojar. 1999. Illustrated Flora of British Columbia. Volume 3. Dicoteyledons (Diapensiaceae through Onagraceae). B.C. Ministry of Environment, Lands and Parks and B.C. Ministry of Forests, Victoria.

Douglas, G.W., D. Meidinger and J. Penny. 2002. Rare native vascular plants of British Columbia. Second Edition. Prov. of BC, Victoria, BC.

Environment Canada. 2003. Canadian Climate and Water Information. Web site: http://www.climate.weatheroffice.ec.gc.ca/prods_servs/index_e.html. [Accessed September 20, 2003].
Grant W.F. 1996. Seed pod shattering in the genus *Lotus* (Fabaceae): A synthesis of diverse evidence. Can. J. Plant Sci. 76:447-456.
Grant, W. F. 1999. Interspecific hybridization and amphidiploidy of *Lotus* as it relates to phylogeny and evolution. Pp. 43-60 *in* P. R. Beuselinck, (ed.), Birdsfoot Trefoil: The Science and Technology of *Lotus*. Crop Science Society and the American Society of Agronomy. Madison, WI.
Grant, W.F. and B.S. Sidhu. 1967. Basic chromosome number, cyanogenetic glucoside variation, and geographic distribution of *Lotus* species. Can. J. Bot. 45: 639-647.
Grant, W.F. and I.I. Zandstra. 1968. The biosystematics of the genus *Lotus* (Leguminosae) in Canada. II. Numerical cytotaxonomy. Canadian Journal of Botany 46: 585-589.
Gray A. 1863. Synopsis of the species of Hosackia. Proc. Academy of Nat. Sci. Philadelphia 15: 346-352.
Greene, E. L. 1890. Enumeration of the North American Loti. Pittonia 2: 133 -150.
Guard, Jennifer. 1995. Wetland Plants of Oregon and Washington. Lone Pine Publishing, Redmond, WA.
Hitchcock, C.L., A. Cronquist, M. Ownbey, and J.W. Thompson. 1961. Vascular Plants of the Pacific Northwest. Part 3: Salicaceae to Saxifragaceae. Univ. Wash. Press, Seattle, WA.
Hooker, W.J. 1829. Botanical Magazine, Vol. 56, Tab. 2913.
Isely, D. 1981. Leguminosae of the United States. III. Subfamily Papilionoideae: tribes Sophoreae, Podalyrieae, and Loteae. In: Mem. New York Bot. Gard. 25(3):181.
Isely, D. 1993. *Lotus.* Pp. 616-622 *in* J. C. Hickman (ed.) The Jepson Manual: Higher Plants of California. Univ. Calif. Press, Los Angeles, CA.
Joffe, A. 1958. The effect of photoperiod and temperature on the growth and flowering of birdsfoot trefoil, *Lotus corniculatus* L. Afr. J. Sci. 1:435-446.
Jones, D.A., S.G. Compton, T.J. Crawford, W.M. Eillis, and I.M. Taylor. 1986. Variation in the color of the keel petals in *Lotus corniculatus* L.: 3. Pollination, herbivory and seed production, Heredity 57:101-112.
Jungen, J.R., P. Sanborn, and P.J. Christie. 1985. Soils of Southeast Vancouver Island Duncan-Nanaimo Area, MOE Technical Report 15. Surveys and Resource Mapping Branch, Victoria, BC.
Kenney, E.A., L.J.P. van Vliet and A.J. Green. 1989. Soils of the Gulf Islands of British Columbia: Volume 4 Soils of Gabriola and lesser islands. Report No. 43, British Columbia Soil Survey. Research Branch, Agriculture Canada, Ottawa, Ont.
Kirkbride, J.H., Jr. 1999. *Lotus* Systematics and Distribution. Pp. 1-20 *in* P.R. Beuselinck, (ed.), Trefoil: The Science and Technology of Lotus. Crop Science Society and the American Society of Agronomy. Madison, WI.
Lacey, C.A., J.R. Lacey, P.K. Fay, J.M. Story, and D.L. Zamora. 1997. Controlling knapweed on Montana rangeland. Circular 311. Montana State University Ext. Service Bulletin. Bozeman, MN.
Lande, R.L. 1995. Mutation and conservation. Conservation Biology 9:782-791.

Lesica, P. and F.W. Allendorf. 1995. When are peripheral populations valuable for conservation? Conservation Biology 9:753-760.
MacDonald, H. A. 1944. Birdsfoot trefoil (*Lotus corniculatus* L.): Its characteristics and potentialities as a forage legume. N.Y. (Cornell) Agr. Expt. Sta. Mem. 261, Ithaca, N.Y.
McKee, G.W. 1963. Influence of daylength on flowering and plant distribution in birdsfoot trefoil. Crop Sc. 3:205-208.
McPhee, M., P. Ward, J. Kirkby, L. Wolfe, N. Page, K. Dunster, N. Dawe, I. Nykwist. 2000. Sensitive Ecosystems Inventory: East Vancouver Island and Gulf Islands 1993-1997. Volume 2: Conservation manual. Technical Report Series No. 345, Canadian Wildlife Service, Pacific and Yukon Region, Delta, BC.
Meidinger, D. and J. Pojar (eds). 1991. Ecosystems of British Columbia. Special Report, Series 6, British Columbia Ministry of Forests, Victoria, B.C.
Morris, P., K.J., Webb, M. P. Robbins, L. Skot, B. Jorgensen. 1999. Application of biotechnology to *Lotus* breeding. Pp. 199-227 *in* P.R. Beuselinck, (ed.), Birdsfoot Trefoil: The Science and Technology of *Lotus*. Crop Science Society and the American Society of Agronomy. Madison, WI.
Morse, R.A. 1958. The pollination of birdsfoot trefoil (Lotus corniculatus L.) in New York State. Pp. 951-953 *in* J. W. Arnold, (ed.) Proc. 10th Internatl. Cong. Ent. Montreal, Canada. June 1958. Int. Cong. Entomol., Montreal, QB.
NatureServe Explorer. 2002. NatureServe Explorer: An online encyclopedia of life. Version 1.7. Arlington, Virginia, USA. Web site: http://www.natureserve.org/explorer/ [Accessed July 11, 2003].
Oregon State University Herbarium Vascular Plant Specimen Database. 2002. Corvallis, Oregon, USA. Web site: http://oregonstate.edu/dept/botany/herbarium/db/vasc_plant.html. [Accessed July 11, 2003].
Ottley, A.M. 1923. A revision of the Californian species of *Lotus*. University of California Publications in Botany 10 (3): 189-305.
Ottley, A.M. 1944. The American Loti with special consideration of a proposed new section, Simpeteria. Brittonia 5(2): 81-123.
Ottley, A.M. 1951. *Lotus*. Pp. 547-556 *in* W.L. Jepson, (ed.) A manual of the flowering plants of California. 3rd Print. Univ. of California Press, Berkeley.
Pojar, J. 1999. Fabaceae. Pp 64-180 *in* Illustrated Flora of British Columbia. Volume 3. Dicotyledons (Diapensiaceae through Onagraceae). Edited by G.W Douglas, D. Meidinger and J. Pojar, British Columbia Ministry or Environment, Lands and Parks, British Columbia Ministry of Forests, Victoria, BC.
Polhill, R.M. 1981. Loteae, Coronilleae. Pp. 371–375 *in* R.M. Polhill and P. H. Raven, (eds.) Advances in legume systematics, Part 1. Int. Legume Conf. Kew. 1978. Royal Botanic Gardens, Kew.
Polhill, R.M. 1994. Classification of the Leguminosae. Pp. 35–36 *in* I.W. Southon, (compiler) F.A. Bisby, J. Buckingham & J.B. Harborne, (ed.), Phytochemical Dictionary of the Leguminosae. Chapman & Hall, London.

Ryan, M. and G.W. Douglas. 1994. Status report on the Seaside birds-foot lotus, *Lotus formosissimus* Greene. Unpublished report submitted to the Committee on the Status of Endangered Wildlife in Canada, Ottawa. British Columbia Conservation Data Centre, Victoria, BC.

Scoggan, H.J. 1978. The Flora of Canada, Part 3 - Dicotyledoneae (Saururaceae to Violaceae). National Museum of Natural Sciences Publications in Botany, No 7(3), National Museums of Canada, Ottawa, ON.

Southwest Centre for Environmental Research and Policy and Instituto de Culturas Nativas de Baja California. 2003. Anthropology of Baja California. Web site: http://www.bajacalifologia.org/english/index.htm. [Accessed July 28, 2003].

St. John, H. 1956. Flora of southeastern Washington and of adjacent Idaho. Students' Book Corporation, Pullman, WA.

Stebbins, G.L. 1957. Self-fertilization and population variability in higher plants. Am. Naturalist, 91: 337-353.

Taubert, P.H.W. 1891-1894. Leguminosae. Nat. Pflanzenfam. 3(3):370-388.

Torrey, J. and A. Gray. 1838. A Flora of North America. Volume 1. Part 1. Wiley & Putnam, New York, N.Y.

University of Washington Herbarium (WTU) Database. 2002. University of Washington Herbarium, University of Washington, Seattle, WA, USA. Web site: http://herbarium.botany.washington.edu/index.htm. [Accessed July 11, 2003].

United States Fish and Wildlife Service (USFWS). 1988. National list of vascular plants that occur in wetlands. US Fish and Wildlife Service Biological Report 88(24).

United States Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS). 2002. The PLANTS Database, Version 3.5. Web site: http://plants.usda.gov. National Plant Data Center, Baton Rouge, LA 70874-4490 USA. [Accessed: July 26, 2003].

Vetter, J. 2000. Plant cyanogenic glycosides, Toxicon 38(1):11-36.

Ward, P., G. Radcliffe, J. Kirkby, J. Illingworth, C. Cadrin. 1998. Sensitive Ecosystems Inventory: East Vancouver Island and Gulf Islands 1993-1997. Volume 1: Methodology, ecological descriptions and results. Technical Report Series No. 320. Canadian Wildlife Service, Pacific and Yukon Region, BC.

Watson, S. 1876. Hosackia. Pp. 133-139 in W.H. Brewer, S. Watson and A. Gray (ed.) Botany of California. Vol. 1. Welch, Bigelow, & Co. Univ. Press, Cambridge, MA.

Young, J.A. and C.G. Young. 1986. Collecting, processing and germinating seeds of wildland plants. Timber Press, Portland.

Zandstra, I.I. and W.F. Grant. 1968. The biosystematics of the genus *Lotus* (Leguminosae) in Canada. I. Cytotaxonomy. Canadian Journal of Botany 46: 557-583.

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COLLECTIONS EXAMINED

The following collections were consulted:

- Royal BC Museum Herbarium
- University of British Columbia Herbarium