

COSEWIC
Assessment and Update Status Report

on the

Golden Paintbrush
Castilleja levisecta

in Canada



ENDANGERED
2007

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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Golden paintbrush — J.R. Janish from Hitchcock *et al.* 1959, with permission.

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COSEWIC Assessment Summary

Assessment Summary – November 2007

Common name

Golden paintbrush

Scientific name

Castilleja levisecta

Status

Endangered

Reason for designation

The species is a perennial hemiparasitic herb of maritime meadows found within the Garry oak ecosystem of southeastern Vancouver Island. The species has lost most of its historic populations, having once been known from 7 locations. One small population was extirpated in recent years. The species is presently reduced to two populations on two small islands in the Victoria area. The spread of invasive alien plants continues to place the species at risk on Trial Island.

Occurrence

British Columbia

Status history

Designated Threatened in April 1995. Status re-examined and designated Endangered in May 2000 and in November 2007. Last assessment based on an update status report.



COSEWIC
Executive Summary

Golden Paintbrush
Castilleja levisecta

Species information

Golden paintbrush (*Castilleja levisecta*) is a perennial herb, usually producing several clustered stems from a common base. The hairy leaves are alternate and attached to the stem. The lower leaves are simple and narrow while the upper leaves are egg-shaped and have 1-3 pairs of short lateral lobes. The inflorescence is a prominently bracted terminal spike. The bracts are hairy, large, golden yellow, blunt and about as wide as the upper leaves. The tips of the bracts have 1-3 pairs of short lobes. The flowers are largely concealed by the bracts. The corolla consists of fused petals that form a 2-lipped structure at the end of a corolla tube. The upper lip is beak-like and 3-4 times as long as the lower lip. There are four stamens and a single stigma and style. Fertilized ovaries develop into a dry capsule that contains 70-150 minute seeds which have a loose, net-veined seed coat.

Golden paintbrush has a chromosome count of $2n=24$. Studies have shown that exceptionally high levels of genetic diversity are maintained within the species compared with other narrowly endemic plant species. The Trial Island population, though one of the most geographically isolated, was the most genetically diverse and showed relatively low levels of genetic divergence. In contrast, the Alpha Islet population showed the second highest level of genetic convergence but only middling levels of genetic diversity.

Distribution

The species occurs at low elevations west of the Cascade Range from Vancouver Island to Linn County, Oregon. In Canada, Golden paintbrush is found only on small islands offshore of Victoria, British Columbia. The two extant populations are approximately 7 km apart and the extent of occurrence is about 2.2 km². The historic extent of occurrence appears to have been approximately 100 km². The area of occupancy is a maximum of 4 km² when based on a 2 km x 2 km grid.

Habitat

In Canada, golden paintbrush occurs in maritime meadows. Summer temperatures are greatly moderated by proximity to the ocean. Coastal fogs bring heavy dew in the late summer and early fall, stimulating germination and breaking shoot dormancy in many perennials even as inland areas remain dry and brown. Coastal fogs and the proximity to shoreline also tend to moderate winter frosts (particularly at night), retard the accumulation of heat and may slow down the development of plants, particularly in the late spring. Maritime meadows may be largely free of woody vegetation for a variety of reasons, including strong summer moisture deficits (particularly on wind-exposed sites and/or those with thin, coarse-textured soils), salt spray and a long history of burning by First Nations. These forces may act alone or in concert, consequently some maritime meadows are subject to forest ingrowth while others remain open despite fire suppression.

The amount of potential habitat on southeast Vancouver Island and the adjacent offshore islands has declined greatly over the past century as maritime meadows have been developed for residential and recreational use. There are approximately 24 ha of maritime meadow habitat within the current range of golden paintbrush in Canada. The distribution of golden paintbrush in Canada lies at the heart of one of North America's fastest growing regions. As a result, there will be continued pressure to develop maritime meadow habitat capable of supporting the species.

Approximately 90% of the current area of occupancy was subject to long periods of livestock grazing in the past and now has vegetation dominated by invasive grasses and forbs as a result. An even greater proportion of potential, but unoccupied, habitat has been grazed by livestock in the past; and is now also dominated by invasive grasses and forbs. Even areas that do not appear to have been grazed in the past have been altered as a result of invasion by herbaceous non-native species, which may still be increasing in abundance.

Burning by First Nations, to improve camas crops, maintained maritime meadow habitat in the past. Fire suppression now favours the development of dense patches of native shrubs and trees where golden paintbrush cannot survive.

Biology

Shoot dormancy begins to break as early as mid-September, and by January most shoots have broken dormancy. Most shoots begin to elongate in March, as the leaves fill out and internodes elongate. Flowering peaks in April and May. Green fruits develop from May to July and ripe, undehisced fruit are usually present from July to early September. Seeds are gradually shed until late November or December, at which point most ripe seeds have dispersed. The seeds are minute, lack adaptations to assist in long-distance dispersal, and appear to be shed when wind shakes the ripened plants.

Golden paintbrush, as a taprooted perennial, is incapable of clonal growth through asexual reproduction.

Herbivory by mammals and arthropods may have a negative effect on the species, but the Canadian populations occur on islands free of mammalian herbivores and arthropod herbivory has only a minor impact.

Golden paintbrush is a hemiparasite, containing chlorophyll and fixing carbon through photosynthesis but receiving water and nutrients through parasitic root connections. It probably parasitizes a broad variety of species.

Population sizes and trends

Golden paintbrush has been reported from eight locations in Canada, only two of which have extant populations. Based on the most recent data there was a total of 3,361 flowering plants in Canada in 2006. This appears to represent a population decline of about 25% over the past 10 years, primarily at Alpha Islet. The potential for a rescue effect is slight because nearby populations in the United States are small and separated by over 10 km of open ocean, and because the seeds are poorly adapted to long-distance transport.

Limiting factors and threats

Apart from the threats to habitat – discussed above – golden paintbrush has been threatened in the past by spring and early-summer mowing, herbivory and trampling.

Special significance of the species

Canadian populations of golden paintbrush have a very high conservation value because they represent approximately 20% of the entire global population of a narrowly-distributed endemic. In some areas, golden paintbrush may have been an important host plant of Taylor's Checkerspot, a Nationally Endangered butterfly.

Existing protection or other status designations

The Nature Conservancy has ranked golden paintbrush as globally critically imperilled. It is listed as Threatened under the U.S. Endangered Species Act. In 2000, COSEWIC ranked golden paintbrush as Endangered in Canada based on a report prepared in 1995.



COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS (2007)

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

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

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

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



Environment Canada
Canadian Wildlife Service

Environnement Canada
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Canada

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

**Update
COSEWIC Status Report**

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2007

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SPECIES INFORMATION

Name and classification

Scientific name: *Castilleja levisecta* Greenm.

Common names: golden paintbrush, golden Indian paintbrush

Family: Orobanchaceae, broomrape family

Major plant group: Eudicot flowering plant

Golden paintbrush is a well-defined species with no commonly used synonyms or infraspecific elements (ITIS 2006).

Morphological description

Golden paintbrush is a perennial herb from a somewhat woody base that usually produces several clustered stems (Figure 1). Flowering shoots tend to be 10-50 cm tall, unbranched, and sticky with long, soft, glandular hairs (especially near the top of the stem). The leaves are alternately arranged along the stem and usually hairy. The lower leaves are narrowly lance-shaped, grading upwards into oblong-egg-shaped leaves with 1-3 pairs of short lateral lobes. The inflorescence is a prominently bracted terminal spike. The bracts are hairy, large, golden yellow, blunt and about as wide as the upper leaves. The tips of the bracts have 1-3 pairs of short lobes. The flowers, which are largely concealed by the bracts, are bilaterally symmetric. The calyx (outer circle of flower parts) is long-hairy and deeply split into two lobes, each of which is narrowly divided into 2 linear, blunt segments. The corolla, lying inside the calyx, consists of fused petals that form a 2-lipped structure at the end of a corolla tube. The upper lip is beak-like and 3-4 times as long as the lower lip. There are four stamens and a single stigma and style. Fertilized ovaries develop into a dry capsule that contains 70-150 minute seeds which have a loose, net-veined seed coat. The large golden yellow bracts of the inflorescence distinguish golden paintbrush from other closely related species within its range in Canada (Douglas *et al.* 2000).

Genetic description

Golden paintbrush has a chromosome count of $2n=24$ (Heckard *ex* Egger pers. comm. 2006). Studies of allozyme diversity in golden paintbrush across its global range determined that exceptionally high levels of genetic diversity are maintained within the species compared with other narrowly endemic plant species. The high levels of genetic diversity are attributed to the fact that several populations are quite large, multiple generations exist within populations, that the species are perennial, and that genetic diversity may be preserved through seed-banking. The Trial Island population, though one of the most geographically isolated, was the most genetically diverse and showed relatively low levels of genetic divergence. In contrast, the Alpha Islet population showed the second highest level of genetic convergence but only modest levels of genetic diversity (Godt *et al.* 2005).

Designatable units

There is only a single designatable unit since the two extant populations occur within a small geographical area in the same ecozone.

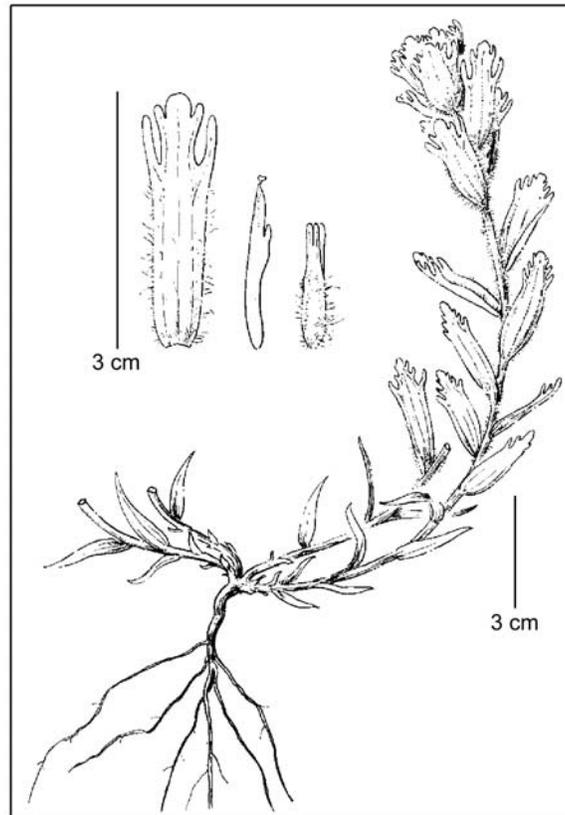


Figure 1. Illustration of golden paintbrush growth form and enlarged floral parts: floral bract (left), a single corolla (centre), and a calyx (J.R. Janish from Hitchcock *et al.* 1959 with permission).

DISTRIBUTION

Global range

Golden paintbrush occurs at low elevations west of the Cascade Range from Vancouver Island to northwestern Oregon (Fig. 2; see also Hitchcock *et al.* 1959)

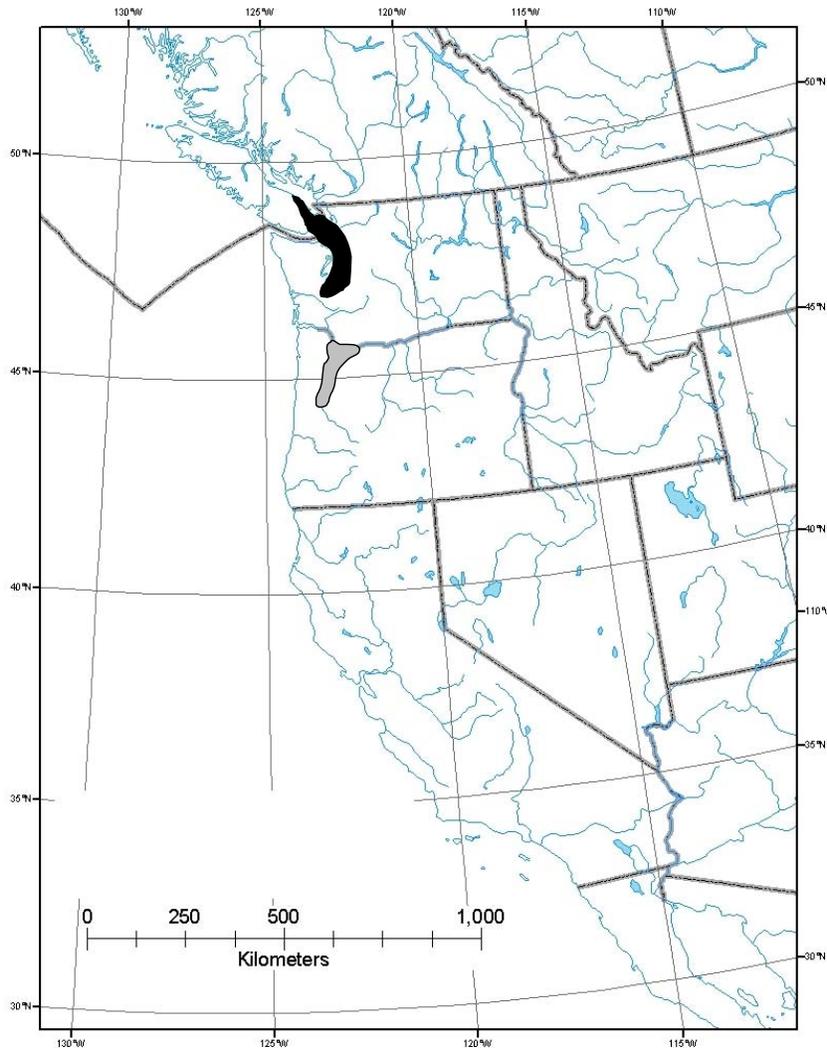


Figure 2. Global distribution of golden paintbrush (black shaded area indicates contemporary range; grey shaded area shows location of extirpated populations from Columbia Gorge southwards; adapted from Caplow 2004).

Canadian range

In Canada, golden paintbrush is found only on small islands offshore from Victoria, British Columbia (Fig. 3). The two extant populations are approximately 7 km apart and the Extent of Occurrence, adjusted by deducting areas of open ocean, is about 2.2 km². If one accepts the (northernmost) record from Wellington (near Nanaimo), then the historic extent of occurrence was approximately 600 km² (after adjustment). If the Wellington report is rejected (see below) then the historic extent of occurrence was approximately 100 km² (after adjustment). Based on the use of a 1 km square overlay grid, the Area of Occupancy for the two extant sites is 2 km² and based on a 2x2 km grid is 4 km².

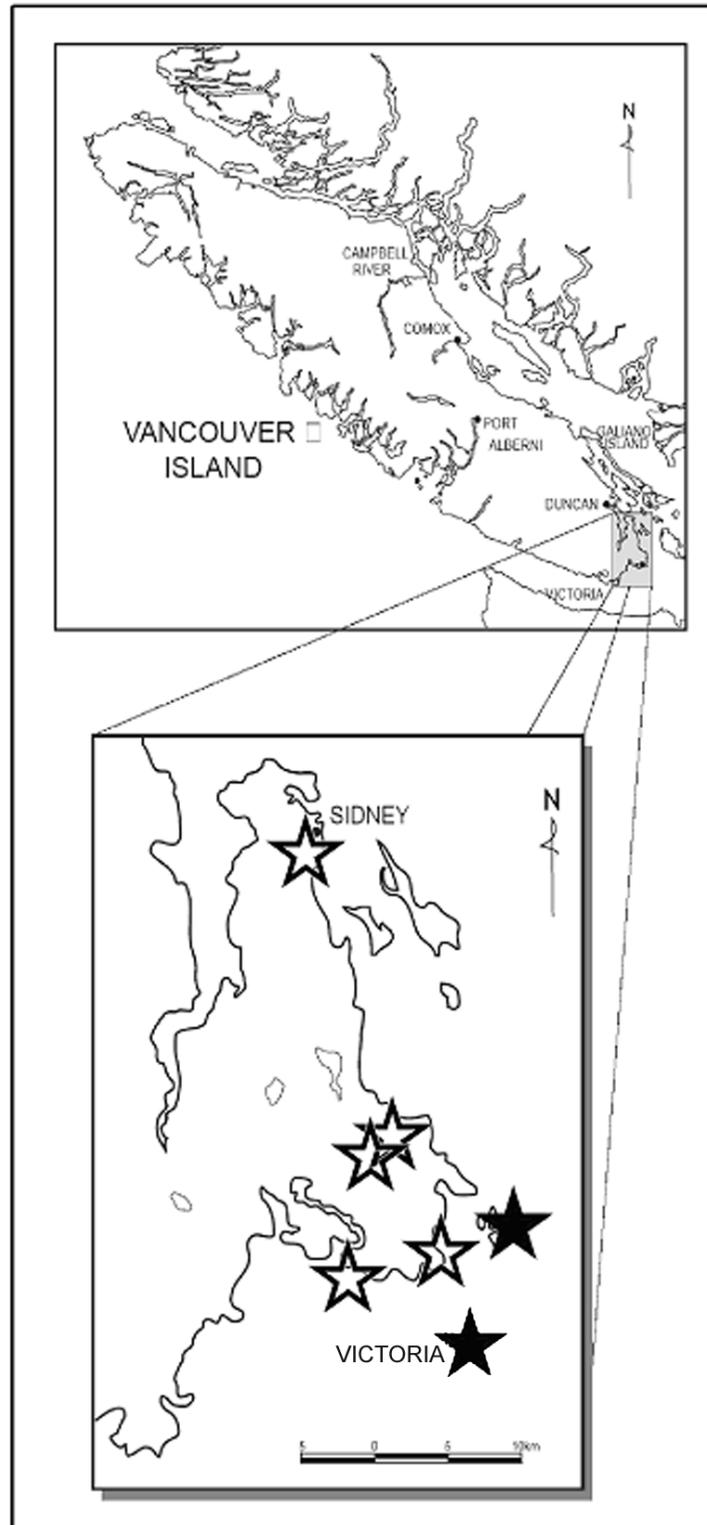


Figure 3. Distribution map of golden paintbrush in Canada (solid stars indicate extant locations; open stars represent extirpated populations).

HABITAT

Habitat requirements

In Canada, golden paintbrush is restricted to maritime meadows associated with Garry oak ecosystems. These are low-elevation (< 30 m), herb-dominated ecosystems largely confined to coastal situations (within 3 km of the shoreline) along southeastern Vancouver Island and a subset of islands in the Strait of Georgia, Haro Strait and the Strait of Juan de Fuca. Summer temperatures are greatly moderated by proximity to the ocean. Coastal fogs bring heavy dew in the late summer and early fall, stimulating germination and breaking shoot dormancy in many perennials even as inland areas remain dry and brown. Coastal fogs and the proximity to shoreline also tend to moderate winter frosts (particularly at night), retard the accumulation of heat and may slow down the development of plants, particularly in the late spring. Maritime meadows may be largely free of woody vegetation for a variety of reasons, including strong summer moisture deficits (particularly on wind-exposed sites and/or those with thin, coarse-textured soils), salt spray and a long history of burning by First Nations. These forces may act alone or in concert, consequently some maritime meadows are subject to forest ingrowth while others remain open despite fire suppression (Parks Canada 2006).

Habitat trends

Habitat loss

The amount of potential habitat on southeast Vancouver Island and the adjacent offshore islands has declined greatly over the past century as maritime meadows have been developed for residential and recreational use. There are no reliable estimates of the rate of loss of maritime meadows and it is difficult, if not impossible, to determine the original extent of this ecosystem type. The proportion of maritime meadows which has been lost probably exceeds the rate of loss of Garry oak ecosystems in Victoria because the maritime meadows were more concentrated along the desirable shoreline locations and provided more level building sites. The extent of Garry Oak ecosystems in Victoria decreased 95% from 10,510 ha in 1800 to 512 ha in 1997 (Lea 2002). This loss is almost entirely attributable to agricultural conversion followed by residential and recreational development.

Surveys conducted in support of this status report showed that there are only approximately 24 ha of maritime meadow habitat within the current range of golden paintbrush in Canada. If one rejects the Wellington report (apparently based on a misidentification) there are only approximately 27 ha of maritime meadow habitat within the entire historic range of the species in Canada.

The distribution of golden paintbrush in Canada lies at the heart of one of North America's fastest growing regions. The population of metropolitan Victoria has increased from approximately 180,000 in 1966 to 338,738 in 2005 and is projected to increase to 407,600 by 2026 (CRD 2006). The most expensive and sought-after properties are ocean frontage where golden paintbrush commonly occurs. As a result, there will be continued pressure to develop maritime meadow habitat capable of supporting the species.

Habitat invasion by exotic species

Golden paintbrush is now restricted to open meadows a few metres above sea level on offshore islands and islets. There have been long periods of livestock grazing in approximately 90% of the current area of occupancy as well as much of the apparently suitable, but unoccupied habitat within its extent of occurrence. Invasive grasses and forbs have entered and now dominate much of the area that has been grazed. Even areas of suitable habitat that were not grazed have often been invaded by exotic plants (pers. obs.).

Several invasive woody and semi-woody species have invaded maritime meadow habitat in the historic range of golden paintbrush. The following species already occur within populations of golden paintbrush and are frequent in similar maritime meadows.

Scotch broom (*Cytisus scoparius*) is present at all sites and in some places it has increased to the point where there is little if any native vegetation under its canopy. Where it has not yet created a closed canopy, size-class distributions suggest its cover is increasing rapidly. Attempts to control Scotch broom have had little success. Most control efforts have involved uprooting which creates soil disturbances that favour invasion by rapidly dispersed invasives. Efforts to control the species by stem-cutting have failed because it resprouts prolifically from cut stumps. In almost every case, control efforts have been followed by heavy recruitment from the large, long-lived soil seed bank (pers. obs.). Recruits may begin reproducing when as little as 3 years old (Bossard n.d.).

Gorse (*Ulex europaeus*) is an increasing threat to maritime meadow habitats. It spreads more slowly than Scotch broom because its seeds are not dispersed as far from the parent plant. It has become established on most maritime meadow sites in the current golden paintbrush area of occupancy and some of the older populations now form a continuous canopy cover (pers. obs.). Where it is established, gorse quickly forms a dense canopy and produces a thick layer of acidic litter that discourages the growth of all other species (see William 1983). Gorse is even more difficult to control than Scotch broom, because it quickly establishes branching rhizome and root systems that are not easily removed.

English ivy (*Hedera helix*) is the third major woody invasive of maritime meadows. It is less widespread than Scotch broom but appears to be increasing its distribution and may soon be present on most sites. Once established, it spreads rapidly to blanket the herb layer. Rooting readily from even small rhizome fragments, it is even more difficult to control than Scotch broom and gorse (pers. obs.).

Other serious and widespread woody invaders of maritime meadow habitats include spurge-laurel (*Daphne laureola*) and Himalayan blackberry (*Rubus armeniacus*). These species appear to present serious threats to maritime meadow ecosystems and the former appears to be rapidly spreading across the region. As well, a few meadows have significant infestations of English holly (*Ilex aquifolium*) and *Cotoneaster* sp. (pers. obs.).

Habitat changes related to fire

Burning by First Nations, to improve camas bulb crops, maintained maritime meadow habitat in the past. Fire suppression now favours the development of dense patches of native shrubs and trees where golden paintbrush cannot survive. Paradoxically, an attempt to improve camas harvest by restoring fire has favoured invasion by rapidly dispersing non-native grasses and forbs rather than restoring the native plant cover (pers. obs.).

Protection/ownership

One of the extant populations lies entirely within an Ecological Reserve managed by BC Parks. The other population is split between another Ecological Reserve, a Canada Coast Guard site and a communications lease on BC crown land. Plants on ecological reserves are protected under the BC *Parks Act* and plants on the Canada Coast Guard site are protected under the *Species at Risk Act*. Recently, BC Parks and the Canada Coast Guard have taken steps to control invasion by woody species. In contrast, maritime meadow habitat on the communications lease that is occupied by golden paintbrush has no formal protection. Habitat quality on the communications lease is declining as the cover of gorse and Scotch broom increases. Operational activities on the communications lease (e.g. trail maintenance and storage of supplies and waste) have directly impacted habitat quality (pers. obs.).

Most of the unoccupied maritime meadow habitat that remains within the extent of occurrence is in municipal parks, which lack formal policies to protect species at risk. Nevertheless, most of these municipalities have taken measures to map species at risk and some have established programs to try to protect maritime meadow habitat by controlling invasive shrubs (pers. obs.).

Federal lands occurrence

One extant population (Trial Island) extends onto federal lands.

BIOLOGY

General

There is extensive published information on the reproduction and dispersal, germination, seedling ecology, survivorship, herbivory and physiology of golden paintbrush in Canada and adjacent areas of the United States. Much of the information from U.S. studies is summarized by Caplow (2004) and Chappell and Caplow (2004). Information on the phenology and population biology of Canadian populations is found in Fairbarns (2005a). The average age of mature individuals in the population has not been determined.

Life cycle and reproduction

Shoot dormancy begins to break as early as mid-September, when the soil remoistens following the end of the summer drought. By January, most shoots have broken dormancy. During the winter months, most fresh shoots merely consist of a congested mass of reduced leaves at the base of the plant. Most shoots begin to elongate in March, as the leaves fill out and internodes elongate. The first floral buds can be detected as early as March and flowering peaks in April and May, although flowering usually continues into June and flowers may continue to develop well into July in favourable years. Green fruits develop from May to July and ripe, undehisced fruit are usually present from July to early September. Most capsules begin to dehisce from late August through September and seeds are gradually shed until late November or December, at which point most ripe seeds have dispersed. The seeds are minute, lack adaptations to assist in long-distance dispersal, and appear to be shed when wind shakes the ripened plants. Canadian plants produce an average of 35 capsules per genet and capsules had an average of 80 seeds (Fairbarns 2005a). Seed viability varies among populations and germination rates of 39%-96% were observed in fresh seeds of plants from south Puget Sound (Wentworth 1994, Caplow 2004, Kaye 2001).

Seedlings are inconspicuous in the field and germinants are rarely observed in natural conditions (pers. obs., Pearson pers. comm. 2005). Experimental seeding with up to 1,000 seeds per square metre have resulted in very low rates of germination and establishment (Fairbarns 2005b, Pearson and Dunwiddie 2003).

Golden paintbrush, as a taprooted perennial, is incapable of clonal growth by asexual reproduction.

Herbivory

Tent caterpillars (*Malacosoma* sp.) and spittlebugs (Cercopidae) have been observed feeding on Canadian plants. The former tend to cause moderate damage to a small proportion of the population while the latter are not abundant and likely have little effect (pers. obs.). Mammals, including deer, rabbits and voles are also reported to graze on golden paintbrush in some areas (USFWS 2000) and may have played a role in the loss of some Canadian populations, but the extant Canadian populations occur on islands which lack mammalian herbivores.

Interspecific interactions

Members of the genus *Castilleja* are hemiparasites, containing chlorophyll and fixing carbon through photosynthesis but receiving water and nutrients through parasitic root connections (Kuijt 1969). Despite their photosynthetic abilities, some related hemiparasites may also obtain photosynthates from their hosts (Atsatt 1970). Many hemiparasites may obtain secondary compounds from their host plants. These can reduce herbivory without affecting pollinators. It appears that alkaloids may be taken up in the leaves and outer floral tissues of some species but not by their nectar, which has the ultimate effect of increasing seed production and improving fitness (Adler 2000, Adler and Wink 2001, Boros *et al.* 1991).

Related hemiparasites in the *Castillineae* have been shown to be facultative hemiparasites capable of growing and producing flowers in the absence of a host, but shoot mass tends to be much higher in the presence of a host (Matthies 1997).

Grassland relatives in the genus *Orthocarpus* form haustorial connections (root grafts) with a number of species including annuals and perennials of the legume, grass, composite and many other families. Not all plants are equally good hosts – some appear to reduce reproductive potential. The parasitic habit is unlikely to be a limiting factor given the diversity of potential hosts intermixed within the Canadian populations of golden paintbrush.

Species of *Castilleja* may serve as a secondary host for larvae of the Taylor's Checkerspot (*Euphydras editha taylori*) if its primary food source (*Plantago* spp.) withers before the onset of diapause (Vaughan and Black 2002). This butterfly (Endangered in Canada) formerly occurred on Trial Island, where golden paintbrush may have been an important food source.

Fruit set is low in the absence of pollinator visitation (Wentworth 1994) but pollinators (primarily bees) do not appear to be limiting in extant Canadian populations (pers. obs.).

Adaptability

Plants have been successfully propagated from seed and outplanted in the autumn (Caplow 2004).

POPULATION SIZES AND TRENDS

Search effort

Golden paintbrush has distinctive, showy flowers that attract attention and are not easily overlooked. Suitable sites have been surveyed repeatedly since the early 1980s in a series of projects designed to document the distribution of rare plants of maritime meadows on southeast Vancouver Island and the Gulf Islands. The principal investigators included Adolf and Oldriska Ceska, Matt Fairbarns, Hans Roemer, Jenifer Penny, Harvey Janszen, Frank Lomer and the late George Douglas, all of whom are/were familiar with the golden paintbrush. Fairbarns (2005c) conducted a detailed search for a number of rare species including golden paintbrush in forty-one meadow complexes on southeast Vancouver Island and offshore islets and islands between 2002 and 2005. The survey included detailed examination of every meadow complex within the known extent of occurrence in Canada, including the single Indian Reserve within the extent of occurrence. No new populations were detected. Private lands and Indian Reserves peripheral to the known extent of occurrence, which only constitute a small proportion of the apparently suitable habitat, have not been surveyed as thoroughly as public lands.

Abundance

In the absence of information on rates of genetic exchange, occurrences of golden paintbrush more than 1,000 m apart are treated as separate locations. On this basis, it has been reported from eight locations in Canada (Table 1), only two of which have extant populations. The Beacon Hill population has not been seen in annual surveys since 1991. The Trial Island population consists of multiple subpopulations (i.e. patches separated by <1,000 m). Based on the most recent data from each site, there was a total of 3,361 flowering plants in Canada occupying about 3.9 ha (0.039 km²).

Fluctuations and trends

The number of mature, reproductive golden paintbrush plants in a population may fluctuate depending on recruitment, maturation, regression and mortality. Large reproductive plants are quite likely to regress in size to small, non-reproductive individuals in unfavourable years (Wentworth 1994). This may provide a partial explanation for the large apparent fluctuations observed in recent years. High values may also be counts of flowering stems while low values are counts of entire plants (individual plants tend to produce 1-3 flowering stems). Changes in the apparent population size on Trial Island may be largely attributable to these two factors, although

there has been an increase in Scotch broom that may have contributed to the recent low numbers. A small component of the reported decline on Alpha Islet may reflect counts of flowering stems vs. entire plants, or regression of mature plants. On the other hand, the magnitude of the change clearly indicates a sharp decline in the population. The magnitude of this decline was so great that the spring count (referred to in Table 1 as 2006a) was followed by an autumn count (referred to in Table 1 as 2006b). Overall, the rate of population decline over the past 10 years was probably about 25% (assuming earlier Alpha Islet counts consisted of plants with an average of 2 flowering stems each).

Table 1. Localities, population and land ownership for golden paintbrush

Location	Year	Collector/ observer	Number of plants ¹ /area	Land ownership/ notes
Trial Island	1961	Calder	Very common	Mixed crown lands ²
	1964	Hett	Unknown	
	1974	Brayshaw	Unknown	
	1992	Douglas	2,560/0.5 ha	
	2002	Douglas	6,450/ ha	
	2006	Fairbarns	3,192 (p)/3.7 ha	
Alpha Islet	1983	Brayshaw	Unknown	Ecological Reserve
	1999	Douglas	2,863 (s)/687 m ²	
	2002	Fairbarns	2,400 (s)/0.2 ha	
	2006a	Fairbarns	169 (p)/0.2 ha	
	2006b	Fairbarns	165 (p)/0.2ha	
Beacon Hill	1896	Anderson	Unknown	Municipal park
	1907	Newcombe	Unknown	
	1908	Porsild	Unknown	
	1969	Clark	Unknown	
	1991	Brayshaw	3/1 m ²	
	2006	Fairbarns	extirpated	
Patricia Bay Hwy	1954	Melburn	Unknown	Unknown
Lost Lake ³	1945	Hardy	Unknown	Unknown
Sidney	1927	Goddard	Unknown	Unknown
Wellington	1898	Fletcher	Unknown	Unknown
Cedar Hill	1887	Macoun	Unknown	Unknown

¹ (s) refers to counts of flowering stems, (p) refers to counts of individual plants, other counts may have been of flowering stems or entire plants

² Population occurs on federal property (Canada Coast Guard light station), provincial ecological reserve and unprotected provincial crown land

³ Blenkinsop Lake

Rescue effect

Extensive floristic surveys have been conducted in nearby areas of Washington State, including the Olympic Peninsula (Buckingham *et al.* 1995), the main islands of San Juan County (Atkinson and Sharpe 1993) and small islets in San Juan County (Giblin pers. comm. 2006). From these studies, it appears that golden paintbrush is absent from the Olympic Peninsula and is very rare in the San Juan Islands (three locations). The San Juan Island populations are small and separated from the nearest portion of the Canadian range by over 10 km of open water. The seeds lack any adaptations to facilitate long-distance dispersal by wind, water or animals. For these reasons, there is negligible opportunity for unassisted gene flow (via seed or pollen) from the United States.

LIMITING FACTORS AND THREATS

Habitat related threats including direct habitat loss and habitat deterioration due to invasion by exotic species and changes resulting from altered fire regimes are discussed above. The following section deals with direct threats to golden paintbrush plants where it currently occurs or existed in the past. The sharp decline on Alpha Islet is unusual because the site is almost free of invasive plants, has not experienced forest or shrub ingrowth, and was not affected by the threats described below (mowing, herbivory, trampling and marine pollution) during the period of decline.

Mowing

The decline and eventual extirpation of golden paintbrush at Beacon Hill Park appears to have been hastened by a summer mowing regime that removed inflorescences before they matured. The last remaining plants occurred in what is still an open meadow apparently capable of supporting golden paintbrush (F. Hook pers. comm. 2005). In contrast, fall mowing may actually favour golden paintbrush by reducing the invasive grasses that make up a significant component in meadow communities (Wilson and Clark 2001) and by increasing seed dispersal within suitable habitat (Caplow 2004).

Herbivory

Herbivory poses a minor threat to extant Canadian populations of golden paintbrush because they occur on small islands with no mammalian herbivores. Invertebrates may feed on tissue but damage is usually slight and localized (see above). Herbivory is a more significant threat to populations in areas with deer, rabbits and voles (Caplow 2004) and may have contributed to the loss of Canadian populations in the past.

Trampling

Trampling and related activities may have presented a minor threat to populations in the past, but the persistence of a population at Beacon Hill Park throughout several decades of intensive use suggests that the species was not particularly susceptible to trampling damage. Regardless, there is little foot traffic in either of the extant populations of golden paintbrush because they occur on islands where visitation is discouraged.

Marine pollution

Douglas and Ryan (1999) suggested that marine pollution may pose a threat to golden paintbrush in Canada because both extant populations occur just above sea level along the shipping lanes that pass through Haro and Juan de Fuca Straits. These are the most crowded and heavily used shipping lanes in North America north of San Francisco. Despite their arguments, it is not clear that marine pollution poses a significant threat to golden paintbrush.

SPECIAL SIGNIFICANCE OF THE SPECIES

Canadian populations of golden paintbrush have a very high conservation value because they represent approximately 20% of the entire global population of a narrowly distributed endemic. Golden paintbrush may have been an important host plant of Taylor's Checkerspot (Nationally Endangered) in some areas.

EXISTING PROTECTION OR OTHER STATUS DESIGNATIONS

NatureServe (2006) has ranked golden paintbrush as "G1" (globally critically imperilled). The Washington Natural Heritage Program has rated it "S1" (critically imperilled) and it is ranked "SH" (historic) in Oregon, where it is now presumed to be extirpated. It is listed as Threatened under the U.S. *Endangered Species Act* (NatureServe 2006).

The British Columbia Ministry of Environment considers golden paintbrush to be a "Red-listed" (threatened/endangered taxon) in British Columbia (Douglas *et al.* 2002). The British Columbia Conservation Data Centre ranks it as "S1" (imperilled) in British Columbia (BC Species and Ecosystems Explorer 2006). COSEWIC ranked golden paintbrush as Endangered in Canada (2000) based on a report prepared by Ryan and Douglas (1995). It was subsequently listed under schedule 1 of the federal *Species at Risk Act* (SARA). Golden paintbrush is the subject of a multi-species recovery strategy along with other maritime meadow species associated with Garry oak ecosystems species (Parks Canada Agency 2006).

Actions to protect golden paintbrush

The Alpha Islet population lies entirely within an Ecological Reserve managed by BC Parks. The Trial Island population is split between another Ecological Reserve, a Canada Coast Guard site and a communications lease on BC crown land. Recently, BC Parks and the Canada Coast Guard have completed a project removing several invasive shrub species (*Cytisus scoparius*, *Ulex europaeus*, *Daphne laureola*, *Ilex aquifolium*, *Rubus armeniacus* and *Cotoneaster* sp.) throughout the Trial Island population of Golden Paintbrush. This project, funded by the Habitat Stewardship Program (Environment Canada), provides an initial step to protection of the population from invasive shrubs. If there is subsequent work to remove these invasive shrubs as they are recruited from the soil seed bank, then the threat posed by woody shrubs will be largely eliminated from Trial Island. The project did not involve removal of *Hedera helix* from the vicinity of Golden Paintbrush plants at Trial Island but funding is being sought to accomplish this in future years.

Plants on the Trial Island and Alpha Islet ecological reserves are protected under the BC *Parks Act* and plants on the Canada Coast Guard site at Trial Island are protected under the *Species at Risk Act*. In contrast, maritime meadow habitat on the Trial Island communications lease that is occupied by golden paintbrush has no formal protection. Operational activities on the communications lease (e.g. trail maintenance and storage of supplies and waste) have directly impacted habitat quality (pers. obs.).

Most of the unoccupied maritime meadow habitat that remains within the extent of occurrence is in municipal parks, which lack formal policies to protect species at risk. Nevertheless, most of these municipalities have taken measures to map species at risk and some have established programs to try to protect maritime meadow habitat by controlling invasive shrubs (pers. obs.).

TECHNICAL SUMMARY

Castilleja levisecta Greenman

golden paintbrush

castilléjie dorée

Range of Occurrence in Canada: British Columbia

Extent and Area information

• <i>Extent of occurrence (EO)(km²)</i>	2.2 km ² but historically likely only 100 km ²
• <i>specify trend (decline, stable, increasing, unknown)</i>	stable over past 10 years
• <i>are there extreme fluctuations in EO (> 1 order of magnitude)?</i>	no
• <i>area of occupancy (AO)</i> [Actual area occupied is about 0.039 km ² but AO is 2 km ² if a 1x1 km grid is used and 4 km ² if a 2x2 km grid is applied]	maximum of 4 km ²
• <i>specify trend (decline, stable, increasing, unknown)</i>	historic declines and 1 recent loss
• <i>are there extreme fluctuations in AO (> 1 order magnitude)?</i>	no
• <i>number of extant locations</i>	2
• <i>specify trend in # locations (decline, stable, increasing, unknown)</i>	stable
• <i>are there extreme fluctuations in # locations (>1 order of magnitude)?</i>	no
• <i>habitat trend: specify declining, stable, increasing or unknown trend in area, extent or quality of habitat</i>	declining in quality

Population information

• <i>generation time (average age of parents in the population) (indicate years, months, days, etc.)</i>	unknown, probably several years
• <i>number of mature individuals (capable of reproduction) in the Canadian population (or, specify a range of plausible values)</i>	currently < 3,400
• <i>total population trend: specify declining, stable, increasing or unknown trend in number of mature individuals</i>	decline
• <i>if decline, % decline over the last/next 10 years or 3 generations, whichever is greater (or specify if for shorter time period)</i>	25% over last 10 years
• <i>are there extreme fluctuations in number of mature individuals (> 1 order of magnitude)?</i>	no
• <i>is the total population severely fragmented (most individuals found within small and relatively isolated (geographically or otherwise) populations between which there is little exchange, i.e., ≤ 1 successful migrant / year)?</i>	yes
• <i>list each population and the number of mature individuals in each</i>	Trial Island: 3,192 Alpha Islet: 169
• <i>specify trend in number of populations (decline, stable, increasing, unknown)</i>	stable over past 10 years
• <i>are there extreme fluctuations in number of populations (>1 order of magnitude)?</i>	no

Threats (actual or imminent threats to populations or habitats)

1. Threats to habitat: habitat degradation due to invasive species, altered fire regimes resulting in spread of shrubs and trees
2. Threats to populations: mowing, herbivory, trampling

Rescue Effect (immigration from an outside source)

Low

• <i>does species exist elsewhere (in Canada or outside)?</i>	yes
• <i>status of the outside population(s)?</i>	globally critically imperiled
• <i>is immigration known or possible?</i>	probably a very rare event
• <i>would immigrants be adapted to survive here?</i>	likely
• <i>is there sufficient habitat for immigrants here?</i>	yes

Quantitative Analysis

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Current Status

COSEWIC: Endangered (May 2000), Endangered (Nov. 2007)
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Status and Reasons for Designation

Status: Endangered	Alpha-numeric code: B1ab(iii,v)+2 ab(iii,v)
Reasons for Designation: The species is a perennial hemiparasitic herb of maritime meadows found within the Garry oak ecosystem of southeastern Vancouver Island. The species has lost most of its historic populations, having once been known from 7 locations. One small population was extirpated in recent years. The species is presently reduced to two populations on two small islands in the Victoria area. The spread of invasive alien plants continues to place the species at risk on Trial Island.	

Applicability of Criteria

Criterion A (Declining Total Population): Not applicable. Decline in last 10 years only 25%.
Criterion B (Small Distribution, and Decline or Fluctuation): Meets Endangered B1ab(iii,v)+2ab(iii,v) due to the very small extent of occurrence and area of occupancy of the 2 remaining populations with continued loss of habitat quality and mature individuals.
Criterion C (Small Total Population Size and Decline): Meets Threatened C1 with a population size >2,500 but <10,000 mature plants and a decline of 25% in the past 10 years.
Criterion D (Very Small Population or Restricted Distribution): Meets Threatened D2 based on the occurrence of only 2 populations with an area of occupancy of <20km ² .
Criterion E (Quantitative Analysis): None available.

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BIOGRAPHICAL SUMMARY OF REPORT WRITER

Matt Fairbarns has a B.Sc. in Botany from the University of Guelph (1980). He has worked on rare species and ecosystem mapping, inventory and conservation in western Canada for approximately 20 years. He was a botanist with the British Columbia provincial government until 2003 and now manages Aruncus Consulting, an independent biological conservation research company.

COLLECTIONS EXAMINED

The following collections were examined:

- Royal BC Museum herbarium (V)
- University of Victoria herbarium (UVIC)