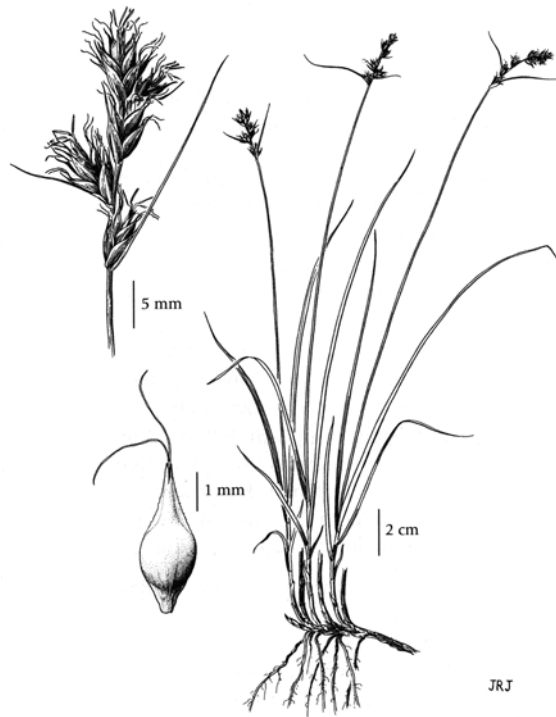


COSEWIC Assessment and Status Report

on the

Foothill Sedge *Carex tumulicola*

in Canada



**ENDANGERED
2008**

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada



COSEPAC
Comité sur la situation
des espèces en péril
au Canada

COSEWIC status reports are working documents used in assigning the status of wildlife species suspected of being at risk. This report may be cited as follows:

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Foothill sedge — Line drawing in Hitchcock *et al.* 1969 and Douglas *et al.* 2001; reproduced with permission from University of Washington Press.

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COSEWIC Assessment Summary

Assessment Summary – April 2008

Common name

Foothill sedge

Scientific name

Carex tumulicola

Status

Endangered

Reason for designation

This perennial species is known from 10 localized and highly fragmented sites in southwestern British Columbia where it occurs in meadows and shrub thickets within Garry oak ecosystems, a critically imperiled habitat in Canada. The total Canadian population likely consists of fewer than 1000 mature individuals. Factors such as competition and habitat degradation from invasive alien plants, altered fire regimes, urbanization, trampling and mowing place the species at risk.

Occurrence

British Columbia

Status history

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



COSEWIC **Executive Summary**

Foothill Sedge *Carex tumulicola*

Species information

Foothill sedge (*Carex tumulicola*) is a grass-like plant in the sedge family that forms loose tufts up to 80 cm high, or sods.

Distribution

The range of foothill sedge extends from southwest British Columbia south to Oregon and California. It has been (possibly erroneously) reported from Idaho. In Canada, it is known only from the southeast coast of Vancouver Island. The actual area of habitat occupied by the species is $\ll 1\text{km}^2$; this has increased from a few m^2 at the original location to an estimated 100 ha. The COSEWIC Area of Occupancy for the 10 populations, if based on a $1\times 1\text{ km}$ grid, is 10 km^2 and 32 km^2 if a $2\times 2\text{ km}$ grid is applied. The Extent of Occurrence (EO) is now estimated at $1,700\text{ km}^2$.

Habitat

In Canada, foothill sedge is known from vernal moist meadows and shrub thickets in Garry oak and associated ecosystems. Increasing urbanization around Victoria and Nanaimo, alien plant invasions, and secondary succession due to fire suppression have altered the ecology of the region to such an extent that the amount of area suitable for supporting this species may now be substantially reduced compared with historical levels.

Biology

Foothill sedge is a perennial that flowers and fruits in mid-to late summer. The flowers are wind-pollinated and the seeds have no innate dispersal mechanism. In addition to reproducing via seed, foothill sedge spreads vegetatively from short rhizomes, and establishes readily from rhizome fragments. It appears able to tolerate high moisture levels in the winter and very low moisture levels in the summer, and is adapted to either sun or shade.

Population sizes and trends

Foothill sedge was first collected in Canada in 1990, but intensive searches for the species did not begin until 1999. By 2006, a total of ten populations had been recognized. In two cases, populations consist of just a single tussock, possibly representing a single individual. Other populations are comprised of single or scattered patches ranging in area from <1 m² to spread out over about 30 ha. Because of the species' rhizomatous habit, obtaining reliable population counts is difficult. However, the total population likely numbers less than 1000 individuals.

Limiting factors and threats

Foothill sedge has only been monitored in Canada for less than a decade, thus the reasons for its present rarity are unclear. Nevertheless, several factors now appear to be threatening its persistence. These include (in approximate order of importance): competition from introduced alien species; altered fire regimes; habitat conversion (urbanization); all-terrain vehicle traffic; hydrologic alterations; trampling and mowing; and loss of habitat due to bank slumping.

Special significance of the species

The species' present disjunct distribution in northwestern North America may be a relict of a once broader distribution that prevailed during the warm, dry, postglacial period, 4,000-6,000 years before present, called the Hypsithermal Interval. Until recently, the species was confused with the European sedge *Carex divulsa*, that has been used for horticultural purposes and some land reclamation work in the Pacific Northwest.

Existing protection or other status designations

Foothill sedge is Red-listed in British Columbia and has a provincial conservation rank of S1 (critically imperiled), but has no species-specific protection in Canada or elsewhere. However, it is possible that the species can be added to the list of species under the BC *Wildlife Amendment Act* (2004). Eight of the ten populations do occur in areas that receive some site protection by virtue of their location in either municipal parks or on DND (Department of National Defence) or Parks Canada Agency property.



COSEWIC HISTORY

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

COSEWIC MANDATE

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

COSEWIC MEMBERSHIP

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

DEFINITIONS (2008)

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

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

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

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



Environment Canada
Canadian Wildlife Service

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Canada

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

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2008

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SPECIES INFORMATION

Name and classification

Scientific name: *Carex tumulicola* Mackenzie

Common names: foothill sedge, Berkeley sedge, splitawn sedge

Family: Cyperaceae, sedge family

Major plant group: Monocot flowering plant

Carex hoodii, the most common relative of *C. tumulicola*, occurs in British Columbia generally south of 55th parallel. Another member of this group, *Carex vallicola*, has been reported from British Columbia only recently from the Ashnola River Valley (Douglas *et al.* 2001).

Carex tumulicola is closely allied taxonomically to *Carex hookeriana* Dewey, which occurs in the Great Plains and is disjunct geographically. *Carex occidentalis* L.H. Bailey, of the southern Rocky Mountains and the Great Basin region, is a third microspecies of this complex (Hitchcock *et al.* 1969).

Morphological description

Carex tumulicola is a grass-like perennial from short rhizomes, forming loose tufts up to about 80 cm tall, and occasionally sods (Fig. 1). The stems are taller than the leaves, arising in circular clusters with less dense centres. Leaves are flat, 1-2.5 mm wide, and 2 to 3 per stem. Each stem bears 3 to 10 spikes. The spikes are small and few-flowered (with male flowers occurring above the female flowers on the same spike), and loosely aggregated into an oblong- or cylindric-shaped head. Bracts are well developed and awnlike, the lower ones generally longer than the inflorescence. The pale green to pale brown perigynia (sacs encasing the ovaries) are egg-shaped or elliptical and 3.5-5 mm long. The scales are brown with a greenish midvein and translucent margins, short-awned, and as long as the perigynia. The fruits consist of nutlike achenes. These are lens-shaped, smooth, and 1.8-2.2 mm long (Douglas *et al.* 2001, Ball 2002).

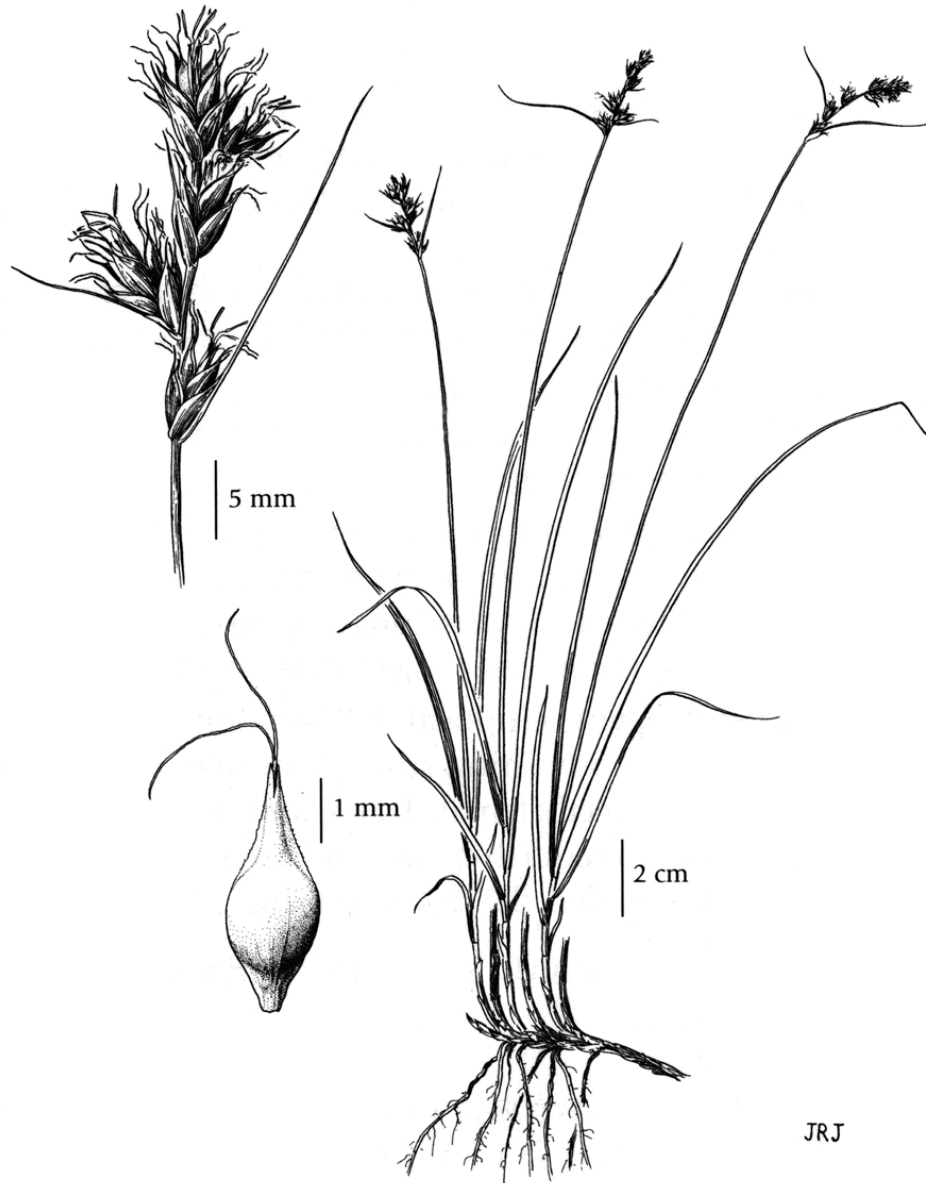


Figure 1. Illustration of *Carex tumulicola*: entire plant, close-up of inflorescence and a single ripe perigynium (line drawing in Hitchcock *et al.* 1969 and Douglas *et al.* 2001; reproduced with permission from University of Washington Press).

Useful field characteristics include its loosely tufted habit and generally well-developed bract surpassing the lower spike.

Many other *Carex* species resemble *C. tumulicola* in general appearance, and positive identification requires mature specimens and use of a technical key and hand lens or microscope. Other sedge species that occur in similar habitats to *C. tumulicola* and that may be mistaken for it include *C. inops* (long-stoloned sedge), *C. hoodii* (Hood's sedge), and *C. vallicola* (valley sedge). *Carex inops* has male and female flowers on separate spikes, hairy perigynia, and 3-angled achenes. *Carex hoodii* has

spikes that are more tightly clustered and more markedly bicoloured. *Carex vallicola* does not get over about 40 cm tall, and has pale scales usually shorter than the perigynia. The latter two species both lack well developed subtending bracts that surpass the lower spikes.

Genetic description

The population genetic structure of *Carex tumulicola* in Canada has not been studied. However, given the species' lack of innate dispersal mechanisms, its non-aquatic habit, and the fairly large distances (10s of kms) that separate many of the *C. tumulicola* populations on southeastern Vancouver Island, genetic interchange among populations likely occurs infrequently, if at all. Because all *Carex* pollen is air borne, it is theoretically possible that wind-aided transport of gametes could be acting to link isolated locations to each other, although the chances of this occurring on a regular basis seem remote. Given the likely very small effective sizes of most populations, loss of vigour due to local inbreeding effects could be a limiting factor for this species in Canada.

Designatable units

A single designatable unit is recognized because of the limited geographical range that occurs within a single COSEWIC national ecological area.

DISTRIBUTION

Global range

Carex tumulicola is found west of the Cascade Mountains from southern Vancouver Island to central California (Fig. 2). The Vancouver Island plants, along with nearby populations in north Puget Sound, are disjunct by approximately 300 km from the species' main range which ends just north of the Columbia River. A 1935 collection from Mount Rainier (J.W. Thompson 12551) has been re-identified as a depauperate specimen of *Carex preslii* (P. Zika, pers. comm. 2004). The species' main range extends upstream along the Columbia River as far as Bingen, southwards along the coast and the Willamette Valley to California. In California, *C. tumulicola* occurs both along the Coastal Ranges and the Sierra Nevada Foothills (Douglas *et al.* 2001, Hitchcock *et al.* 1969, Mastrogriuseppe 1993). *Carex tumulicola* has been reported in Idaho, based on collections from Owyhee county in southwestern Idaho, and historical collections from Bannock and Power counties in the eastern part of the state (Idaho Fish and Game 2004). These reports are suspect, however, and the material should be re-examined to see if they are misidentifications of other, more likely species such as *C. occidentalis* or *C. hookeriana*.

Canadian range

In Canada, *Carex tumulicola* has only been found along the southeast coast of Vancouver Island (Fig. 3). Most known populations occur in or near Victoria. It has been collected as far north as Nanaimo and as far west as Rocky Point (east of Sooke). The nearest U.S. populations occur in the San Juan Islands, only a few km from Victoria. A population is known from Port Townsend, also < 20 km from Victoria.

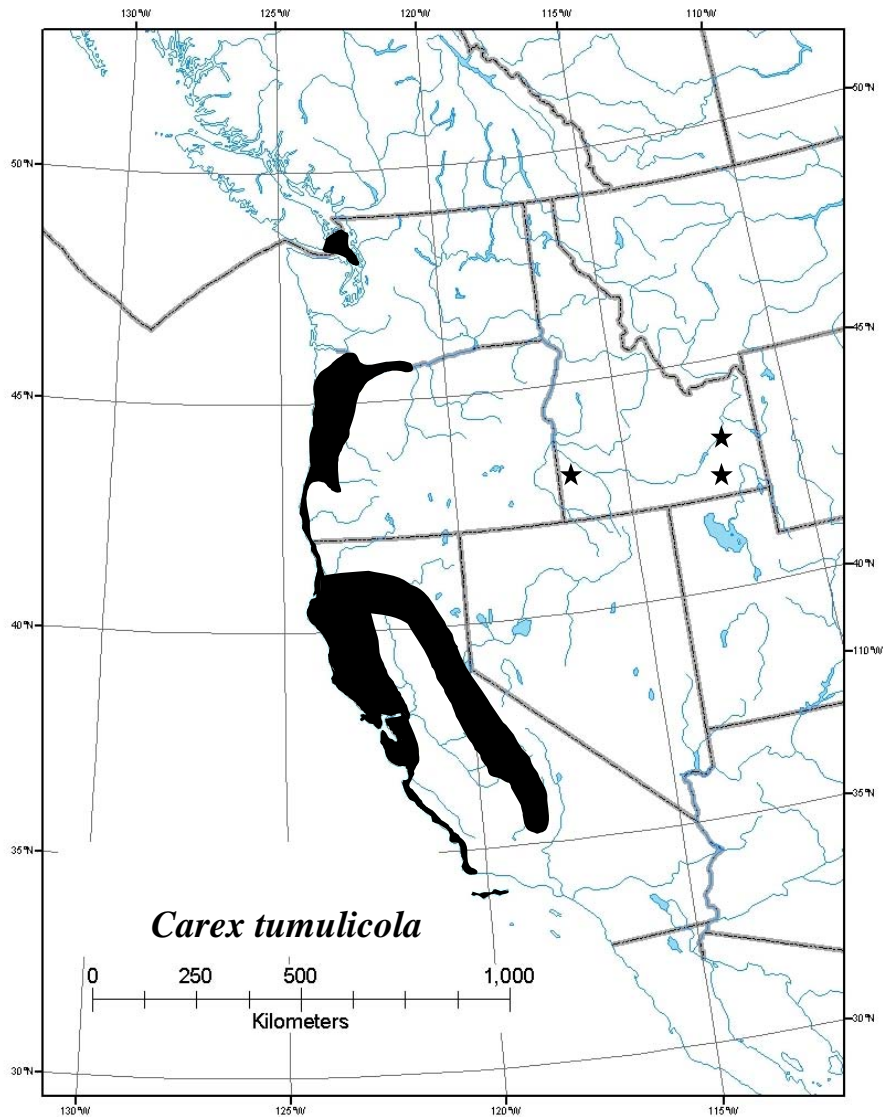


Figure 2. Global range of *Carex tumulicola*. Stars are unconfirmed collections.

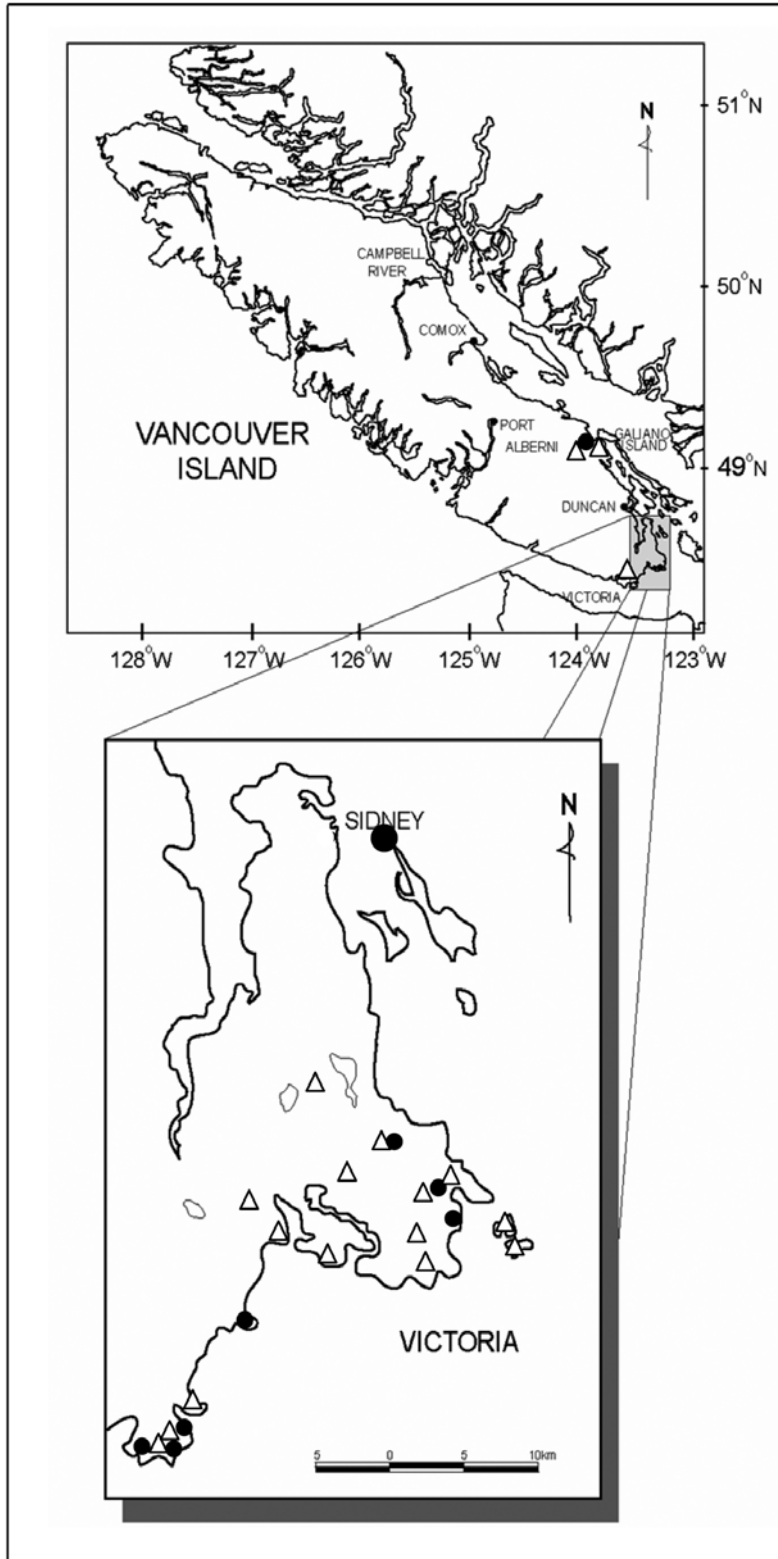


Figure 3. Range of *Carex tumulicola* in Canada. Solid circles: extant populations; white triangles: survey locations where *C. tumulicola* was not found.

Since 1990, when *Carex tumulicola* was first collected on Vancouver Island, the number of known populations¹ in Canada has increased from one to ten. The actual area of habitat occupied by the species is $\ll 1 \text{ km}^2$; this has increased from a few m^2 at the original location to an estimated 100 ha. The COSEWIC Area of Occupancy, if based on a 1x1 km grid, is 10 km^2 and 32 km^2 if a 2x2 km grid is applied. The Extent of Occurrence (EO) is now estimated at $1,700 \text{ km}^2$. These increases almost certainly do not reflect any recent biological expansion in the range of *C. tumulicola*. Rather, they may be presumed to reflect the increased attention and search effort the species has received from local botanists since 1998.

HABITAT

Habitat requirements

Across its range, *Carex tumulicola* is typically found in upland prairies, dry to moist meadows, and open woodlands (Peck 1961, Hitchcock *et al.* 1969, Mastrogiuseppe 1993, Wilson 1999, B. Newhouse, pers. comm. 2001).

In Canada, *Carex tumulicola* is restricted to the dry coastal lowland zone (Coastal Douglas-fir Biogeoclimatic Zone, moist maritime subzone) of southeast Vancouver Island, British Columbia (Douglas *et al.* 2001). This region lies within the rain shadow of the Vancouver Island and Olympic mountains and is characterized by a sub-Mediterranean climate with warm, dry summers and mild, wet winters. The mean annual temperature in Victoria, the core of the Canadian range of *C. tumulicola*, is 10 C . Mean daily temperatures range between 4°C in December and 15.6°C in July. Summer drought is an important feature determining the character of the vegetation in this region. Of the 690 mm of average annual precipitation in Victoria, less than 5% falls during July and August. The annual moisture deficit exceeds 350 mm (McMinn *et al.* 1976, Fuchs 2001). *Carex tumulicola* is not widely distributed throughout the dry coastal lowland, being found only at elevations of less than 50 m and generally within 200 m of the coastline. Its restriction to low elevation coastal sites suggests that poor frost-hardiness may limit its distribution.

¹ Following guidelines set by the BC Conservation Data Centre, "population" is here defined arbitrarily as any locality or group of localities separated from all other localities by a distance of at least 1 km.

The bedrock underlying southeastern Vancouver Island is primarily igneous, metamorphic, and to some extent sedimentary in origin (McMinn *et al.* 1976). Many populations of *Carex tumulicola* occur in openings in Garry oak woodlands, where the soils tend to be Orthic Sombric and Lithic Sombric Brunisols, with a well-developed Ah horizon and Moder to weak Mor humus formations (Roemer 1972). Population #7 occurs on a Lithic Dystric Brunisol overlying gently sloping sandstone or conglomerate (Jungen *et al.* 1985). The soils become moistened with arrival of autumn rains and remain moist (sometimes saturated) through the winter and early spring. Soil moisture levels decline as the summer drought progresses and by mid-summer most of the surrounding vegetation has withered, although the foliage of *C. tumulicola* often remains bright green into the fall.

Carex tumulicola may have been an important species in coastal meadows and prairies of southeastern Vancouver Island prior to European settlement. Currently, *C. tumulicola* persists on San Juan Island, WA (15 km from Victoria) in large patches of several hundred plants in damp, undisturbed meadows, and at lower abundances in more disturbed meadows (P. Zika, pers. comm. 2004). It is one of the few species of native grasses or sedges that could have dominated these systems prior to the arrival of invasive European forage species (Chappell and Caplow 2004).

Population #1

This population consists of several scattered *Carex tumulicola* patches within a remnant Garry oak woodland-meadow complex presently dominated primarily by weedy native and non-native shrubs (e.g., *Symphoricarpos albus*, *Cytisus scoparius*, *Ulex europaeus*) and introduced grasses (e.g., *Holcus lanatus*, *Lolium perenne*, *Agrostis stolonifera*) and herbs (e.g., *Allium vineale*). Several *C. tumulicola* occurrences are in small strips of woodland habitat along the margins of shrub thickets, appearing to persist along the lightly trampled margins of paths where foot-traffic has held back encroachment by shrubs such as *Symphoricarpos albus*. Elsewhere, *C. tumulicola* occurs as small tussocks within meadow fragments (dominated by introduced grasses) where competition is reduced by summer mowing intended to reduce the build-up of fire fuels.

Population #2

A portion of this population is located beside a footpath in an upland Garry oak meadow, with introduced grasses (e.g., *Bromus sterilis*) predominating. The other localities consist of small tussocks in weedy areas along footpaths and roadsides, with understories typically dominated by invasive native and non-native shrubs, grasses and herbs (e.g., *Symphoricarpos albus*, *Rubus discolor*, *Lolium perenne*, *Poa pratensis*, *Agropyron repens*, *Hedera helix*, and *Taraxacum officinale*).

Population #3

This population is located next to a dry, mown trailside in a rocky upland area adjacent to an overgrown bog. Here, *Carex tumulicola* occurs near the trail edge beneath an overstory of *Populus tremuloides* and *Crataegus monogyna* in association with several introduced species of herbs and grasses.

Populations #4 & #5

These populations occur in remnant Garry oak savannah within a few metres of the marine shoreline. Several of the patches are found in grassy swales, dominated by a mix of native and non-native herbs, amid rock bluffs. Other patches occur in mown meadows dominated by non-native grasses and forbs (e.g., *Poa pratensis*, *Bromus hordeaceus*, *Lolium perenne*, *Bromus sterilis*, *Geranium dissectum*, *G. molle*, *Vicia* spp., *Myosotis discolor*, *Trifolium dubium*, and *Cynosurus echinatus*). Associated native species include *Carex macloviana*, *Juncus tenuis*, *Lomatium nudicaule*, *Triteleia hyacinthina*, *Pteridium aquilinum*, *Camassia leichtlinii*, *Cerastium arvense*, and *Plectritis congesta*.

Population #6

This population is located within heavily disturbed meadows near the marine shoreline. The sites have been mown and/or grazed in the past and are dominated by non-native shrubs, forbs and grasses.

Population #7

This population consists of a single tussock growing at the edge of a moist, shrubby (*Symphoricarpos albus*, *Rosa nutkana*, *Crataegus monogyna*) seep within a Garry oak woodland.

Population #8

This population occurs on bare soil in a small opening beneath a mixed second growth forest canopy of *Pseudotsuga menziesii*, *Quercus garryana*, and *Arbutus menziesii*.

Population #9

This population occurs in a grassy, coastal, mesic meadow interrupted with some patches of Scotch broom (*Cytisus scoparius*) and Nootka rose (*Rosa nutkana*).

Population #10

This population occurs on Sidney Spit, owned by Parks Canada, in an abandoned rough (unseeded) grassy pasture with a mix of native plants and a large component of invasive species.

In summary, *Carex tumulicola* tends to occupy meadow and open woodland habitats in Canada, many of which are now dominated by invasive forage species or are being taken over by shrubs and trees. The most vigorous populations tend to occur where tree and shrub cover is slight and where invasive forage grasses are either less common, or subject to mowing.

Habitat trends

The amount of potential habitat has declined substantially over the past century as coastal areas on southeastern Vancouver Island have been developed for residential and recreational use. Less than 1% of the Coastal Douglas-fir zone is currently protected (Eng 1992). Garry oak ecosystems in the Victoria region have declined in area from 10,510 ha in 1800 to 512 ha in 1997, a decrease of nearly 95% (Lea 2002). Even more has been lost since then. Most of what remains has been heavily altered through invasion by exotic grasses and shrubs. Habitats suitable for *Carex tumulicola* were probably never as abundant as Garry oak ecosystems in general. Their habitat has certainly experienced at least an equally sharp decline since price and demand for residential and commercial development are greatest in coastal areas where *C. tumulicola* tends to occur. Specifically, populations #1, 2, 3, & 7 occur in small green spaces within or immediately adjacent to large residential areas built on similar sites that were formerly capable of supporting *C. tumulicola*.

Habitat quality has also declined throughout the coastal meadow and woodland habitats that persist (see threats section below). Fire suppression has favoured in-growth of native and non-native shrubs and trees, reducing light to the forest floor. A number of highly competitive forage grasses and forbs have been deliberately introduced since the mid-19th century and have spread unassisted throughout meadow and woodland habitats (Fuchs 2001). *Carex tumulicola* tends to persist only as small and/or low-vigour populations on sites where there is significant tree or shrub encroachment or where forage grasses and forbs are abundant.

Habitat protection/ownership

The type of land ownership and protection corresponding to each occurrence of *Carex tumulicola* in Canada is shown in Table 1. Of the ten *Carex tumulicola* populations identified to date, three occur in municipal parks within Greater Victoria (with one straddling the boundaries of an educational institution), four are on federal DND land, with one extending onto an adjacent Indian Reserve, one is completely within Indian Reserve lands, one occurs on private land, and one in a National Park. None of the populations is under any legal protection, although several sites are afforded some measure of effective protection from urban and residential development due to their location on managed municipal, DND or Parks Canada Agency lands (Table 1). Federal land managers are generally concerned with the inventory of taxa that are currently designated under federal Endangered Species legislation (SARA) as well as those that are of concern provincially or candidates for SARA designation.

Table 1. General location, first and last observation dates, land tenure, and existing habitat protection for *Carex tumulicola* sites in Canada.

Population / Patches / Subpopulations	General Location	First Obs. & Source¹	Last Obs. & Source¹	Land Tenure	Protection
1a	Oak Bay	~1990 / CTB	N/A	Municipal park	Partial
1b	Oak Bay	2003 / MF-JP	2004 / MM	Municipal park	Partial
1c	Oak Bay	2003 / MF-JP	2004 / MM	Municipal park	Partial
1d	Oak Bay	1999 / AC	2004 / MM	Municipal park	Partial
1e	Oak Bay	2003 / MF-JP	2004 / MM	Municipal park	Partial
1f	Oak Bay	2003 / MF-JP	2004 / MM	Municipal park	Partial
1g	Oak Bay	2003 / MF-JP	2004 / MM	Municipal park	Partial
1h	Oak Bay	2003 / MF-JP	2004 / MM	Municipal park	Partial
1i	Oak Bay	2003 / MF-JP	2004 / MM	Municipal park	Partial
1j	Oak Bay	2003 / MF-JP	2004 / MM	Municipal park	Partial
1k	Oak Bay	2003 / MF-JP	2004 / MM	Municipal park	Partial
1l	Oak Bay	2003 / MFJP	2004 / MM	Municipal park	Partial
1m	Oak Bay	~1990 / CTB	2003 / MF-JP	Municipal park	Partial
1n	Oak Bay	2004 / MM m	2004 / MM	Municipal park	Partial
1o	Oak Bay	2004 / MM	2004 / MM	Municipal park	Partial
1p	Oak Bay	2004 / MM	2004 / MM	Municipal park	Partial
1q	Oak Bay	2004 / MM	2004 / MM	Municipal park	Partial
1r	Oak Bay	2004 / MM	2004 / MM	Municipal park	Partial
1s	Oak Bay	2004 / MM	2004 / MM	Municipal park	Partial
1t	Oak Bay	2004 / MM	2004 / MM	Municipal park	Partial
1u	Oak Bay	2004 / MM	2004 / MM	Municipal park	Partial
1v	Oak Bay	2004 / MM	2004 / MM	Municipal park	Partial
1w	Oak Bay	2004 / MM	2004 / MM	Municipal park	Partial
1x	Oak Bay	2004 / MM	2004 / MM	Municipal park	Partial
2a	Saanich	1998 / AC	2004 / MM	Post-secondary institution	None
2b	Saanich	2004 / MM	2004 / MM	Post-secondary institution	None
2c	Saanich	2004 / MM	2004 / MM	Post-secondary institution	None
2d	Saanich	2004 / MM	2004 / MM	Post-secondary institution	None
2e	Saanich	2004 / MM	2004 / MM	Post-secondary institution	None
2f	Victoria	2003 / AC	2004 / MM	Municipal park	Partial
3	Saanich	1999 / AC	2004 / MM	Municipal conservation area	Partial

Population / Patches / Subpopulations	General Location	First Obs. & Source ¹	Last Obs. & Source ¹	Land Tenure	Protection
4a	Rocky Pt.	1999? / AC?	2004 / MF	DND	Partial
4b	Rocky Pt.	2003? / MF?	2004 / MF	DND	Partial
5 (13 sub- pops)	Rocky Pt.	2003? / MF?	2004 / MF	DND	Partial
6 (several sub-pops)	Rocky Pt.	2004 / MF	2004 / MF	DND / Indian Reserve	Partial
7	Nanaimo	2003 / AC	2003 / AC	Private	None
8	Albert Head	2004 / MM	2005 / MM	DND	Partial
9	Becher Bay	2006 / MM	2006 / MM	Indian Reserve	Partial
10 (6 sub-pops)	Sidney Spit	2005 / AC	2007 / JF	Parks Canada	Partial

¹CTB: C.T. Brayshaw; AC: Adolf Ceska; JF: Jamie Fenneman; MF: Matt Fairbarns; mm: Mike Miller; JP: Jenifer Penny.

The Department of National Defence lands are administered by both the Maritime Forces Pacific (MARFAC) and Canadian Forces Base, Esquimalt (CFB – Esquimalt). The Environmental Science Advisory Committee (ESAC) supports research and inventory on species-at-risk and candidates for species-at-risk designation under SARA. Decisions regarding management of species are considered within the context of the Natural Resources Program and therefore, some needs may not get addressed. Although this species has yet to be SARA-listed, DND has mapped all the known *C. tumulicola* sites on their GIS layers. For the moment the sites on DND lands remain inaccessible to the public and are effectively protected from development.

The three populations occurring on municipal parklands also have no formal protection under park management policies. Portions of Population #2 occur on the campus of a post secondary institution and are afforded neither formal nor informal protection. Population #7 occurs on private land that has been repeatedly proposed for residential development.

Population #1 is under the jurisdiction of the District of Oak Bay, while populations #2 & 3 are managed by the District of Saanich. Because they are located in municipal parks in close proximity to some of the most densely populated areas of Victoria, all three sites experience steady recreational use throughout the year. Here, long term prospects for the survival of the species will be tied closely to any future land use decisions made with regard to the management of these popular areas. A stewardship plan for the municipal park containing Population #1 is currently being drafted jointly by the University of Victoria's Restoration of Natural Systems Program and the Municipality of Oak Bay. The site supporting Population #3 has been designated as a Conservation Area by the Municipality of Saanich, which is currently developing management strategies to protect known occurrences of rare species at the site. Population #10 is on property owned by Parks Canada Agency.

BIOLOGY

There is little published information available on the biology of *Carex tumulicola*. The sections that follow present summary information gleaned from primary sources (floras), published literature on other *Carex* species, personal communications with *Carex* specialists in British Columbia and Oregon, and the authors' own (unpublished) field observations.

Life cycle and reproduction

Carex tumulicola is a tufted perennial herb in the sedge family (Cyperaceae) that flowers in May or June. As with all sedges, the flowers are wind-pollinated. Fruits (achenes) mature during the summer. Seeds are released in the late summer or fall and are primarily gravity-dispersed. It is not known how long the seeds of *C. tumulicola* remain viable in the soil, although some *Carex* species have been shown to form persistent soil seed banks (Nariyasu *et al.* 2001). The timing of germination is also unknown, but presumably occurs in the spring, following the onset of winter rains.

The specific germination requirements of this species are unknown, but recruitment from seed may be infrequent under certain conditions. An attempt to sow native *Carex tumulicola* seeds at Eugene, Oregon as part of a larger wetland mitigation project failed to yield any new recruits by the following year (City of Eugene 2002).

In addition to reproducing sexually via seed, *Carex tumulicola* spreads vegetatively from short rhizomes, and establishes readily from rhizome fragments. Consequently, it is difficult to estimate a generation time (defined by COSEWIC as the average age of parents in the population) for this species.

Herbivory

Many species of *Carex* are ranked equal to the best grasses for forage, as well as in the amount taken by grazing cattle and wild animals; other members of the genus are coarse and of little value as foraging plants (Booth 1950).

The palatability of *Carex tumulicola* to herbivores is not known. The species can presumably withstand occasional grazing, due to its deeply-set rhizomes and growing points and its ability to replenish roots through the growing season. Nevertheless, given its extreme rarity at the local scale, it is unlikely that herbivores are currently exploiting *C. tumulicola* in British Columbia to any great extent. Historically, livestock grazing during the early 20th century may have offset the impact of altered fire regimes at some sites (e.g. Uplands Park) by preventing the intrusion of woody species into open habitats (Fairbarns *et al.* 2003). It is possible that the continued persistence of *C. tumulicola* at these sites is partly related to the lingering effects of this earlier grazing activity. Although the site supporting Population #10 is heavily grazed by introduced fallow deer and a small population of native black-tailed deer, *Carex tumulicola* did not appear to be grazed in 2006 (M. Fairbarns, pers. comm. 2008).

The seeds of *Carex* species are, in general, rich in stored food and are occasionally eaten by wildfowl and other vertebrates (Booth 1950, Holt and van der Valk 2002). It is not known what impact seed predation may be having currently on the local population dynamics of *C. tumulicola*.

Physiology

There is no information on physiology relevant to the assigning of at-risk status in Canada.

Dispersal

There is no specific information available on dispersal patterns in *Carex tumulicola*. *Carex* seeds do not possess any innate dispersal mechanisms, although birds appear to be effective dispersal agents for *Carex* species in general. For example, waterfowl are estimated to be able to transport viable seeds of some wetland species up to 1,400 km following ingestion (Holt and van der Valk 2002). Seed dispersal by adhesion to feathers may be an important method of seed transport, and ants are thought to be key agents in the short-distance dispersal of some *Carex* species (Vellend *et al.* 2000). Because *C. tumulicola* is rhizomatous, dispersal may also depend to some extent on the passive transport of rhizome fragments (e.g. in soil, on vehicles, etc.), but this has not been established.

Interspecific interactions

There is no information on the interactions of *Carex tumulicola* with other species that is relevant to assigning at-risk status in Canada.

Adaptability

Carex tumulicola probably requires moist conditions for germination but, once established, appears tolerant of seasonal drought. The species' rhizomatous habit presumably helps to protect it to some extent from (and perhaps allows it to exploit) surface disturbances such as ground fires, flooding, and trampling.

In the southern part of its range, *Carex tumulicola* has the reputation of being a hardy species that is resilient to disturbance and is able to withstand a range of growing conditions. For example, The Jepson Horticultural Database (Jepson Herbarium 1993) makes note of its "untested" potential in "stabilizing or restoring disturbed or degraded areas." Likewise various California garden catalogues list it as a versatile plant that does well in sun or shade, in dry to boggy or regularly watered areas. These catalogues also state that it is stimulated by periodic cutting/mowing and is capable of reseeding once established. It is generally purchased as rootstocks or cuttings for transplanting. Until recently, some of these garden suppliers appear to have confused *Carex tumulicola* with the European sedge *Carex divulsa*. The statements made in the garden catalogues, above, likely refer to the European species.

The environmental conditions encountered by a species at the edge of its geographic range are often sub-optimal relative to other areas. In cases where ecological marginality coincides with range marginality, peripheral populations may possess reduced demographic latitude for responding to alterations in local conditions or to stochastic disturbances, compared with populations at the core of the range (Lesica and Allendorf 1995). In the case of *Carex tumulicola*, therefore, it would be imprudent to assume that because the species appears characteristically hardy and adaptable in some parts of its range, the same automatically holds true for those populations found at its northern range limit on Vancouver Island. Indeed, the extreme rarity of the species in British Columbia, both in terms of the number of populations and total area of occupancy, would seem to suggest otherwise.

POPULATION SIZES AND TRENDS

Search effort

There are about 70 reported patches of *Carex tumulicola* in Canada, distributed among ten populations (Table 1). A few of these sites have been surveyed on two or more occasions since the late 1990s, when botanists first became alerted to the presence of *C. tumulicola* in Canada (Ceska 2000); other localities are relatively “new” and have only been visited once (Table 1). The surveys were undertaken as part of a series of projects designed to document the distribution of rare plants in open meadows on southeast Vancouver Island and the Gulf Islands. Over the past decade, > 500 person-days have been spent searching for rare species in suitable habitats, spanning 1000 ha of suitable habitat in > 80 sites (Fairbarns *et al.* 2003).

Intensive surveys for *Carex tumulicola* began in 1999, after a student in a summer botany course brought in for identification an unknown sedge that he had collected on the University of Victoria campus grounds. The instructor in the course was A. Ceska, who confirmed the identity of the specimen (Ceska 2000). A follow-up visit to the herbarium of the Royal British Columbia Museum revealed that *C. tumulicola* had already been collected once before on Vancouver Island, in Oak Bay in 1990. However, the original collector, T.C. Brayshaw, was unaware that *C. tumulicola* was rare in British Columbia and therefore did not report his finding (Ceska 2000). Subsequent surveys for the species yielded new records in 1999, 2002, 2003, and 2004 (B.C. Conservation Data Centre 2004).

Approximately ten days of fieldwork, carried out by the authors and others (J. Penny, H. Roemer) in 2003 and 2004 during peak flowering season, focused both on the confirmation of known populations and the search for new ones. As most known populations in B.C. are found in ephemerally moist areas in grassy meadows and open woodlands near the coast, searches for new populations focused on these features. Using aerial photographs and topographic maps, potential habitat areas in the vicinity of known sites at Metchosin, Victoria and Nanaimo were identified and accessed wherever possible (Fig. 3). An area of approximately 200 hectares was searched, yielding three

new populations and numerous new patches (Table 1). Some potential territory was under private ownership with limited access, and was not searched. The search sites included: all of Trial Island and portions of Chatham Island, Rocky Point, Uplands Park, East Sooke Park (Aylard Farm), Mt. Tolmie Park, University of Victoria campus, Rithet's Bog, Albert Head, Christmas Hill, Little Saanich Mt., Mill Hill, Fort Rodd Hill National Historic Site, Joan Point/Harmac, and Harewood Plains.

Carex tumulicola is a highly inconspicuous plant that is difficult to distinguish from other sedges when not in flower. This is presumably one reason why the species has, until recently, escaped notice on southern Vancouver Island. There is thus a chance that additional populations will be found as more habitat is surveyed. Further inventory should be focused in the Southern Gulf Islands, including Sidney Island (subsequent to the completion of this report, a population was reported from Sidney Island), Portland Island, Saturna Island, Pender Island, and Tumbo Island, and other areas around Victoria (subsequent to the completion of this report, a population was also discovered at Becher Bay), including Mt. Douglas, Cedar Hill Golf Course, and Regional Parks (Francis King, Thetis Lake, Elk Lake and Bear Hill). However, it should be noted that search efforts in similar areas have rarely turned up this species.

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

Abundance

Because *Carex tumulicola* is a clonal species that spreads from rhizomes, distinguishing genetic individuals (genets) in the field for the purpose of obtaining population counts is an intractable to impossible undertaking in most cases. In those instances where *C. tumulicola* plants formed discrete tussocks, each tussock was generally considered a single ramet (or the best representative of a mature plant). Where distinct tussocks could not be distinguished, surveyors have usually provided only a rough estimate of the patch size (i.e., in m²). Consequently, there is presently no good estimate available for the total number of *C. tumulicola* genetic individuals (genets) in Canada. Thus far, about 70 patches of *C. tumulicola* have been recorded with a range of about 600 -1500 tussocks in total (Table 2). The number of genetically distinct mature individuals is likely much smaller. The numbers of patches recorded for Population #10, added to the report subsequent to its completion, are based on two observations by different individuals made in 2006 and 2007 (see Table 2).

Table 2. Population summaries for *Carex tumulicola*.

Population	No. of patches/tussocks	Extent of area occupied
1	± 24 patches (40-70 tussocks)	from <1 m ² to a few m ² over an area of 30 ha
2	6 patches (~10 tussocks)	most < 0.5 m ² in extent, distributed among six different sites (subpopulations) over a 0.3 km ² area
3	1 patch (possibly a single genet)	approx. 5 m ²
4	3-5 patches (50-100 tussocks)	1 km stretch of uninhabited coastline
5	13 patches (100-500 tussocks)	from < 1 m ² to several m ² , with one extensive subpopulation scattered through a mowed, 2 ha meadow; the population extends about 800 m along an uninhabited coastline representing about 16 ha of habitat.
6	5-10 patches (50-200 tussocks)	scattered over a 200 m length of coastline.
7	a single tussock (probably one genet)	likely < 1m ²
8	a single patch (three tussocks)	approx. 2m ²
9	7 patches (280-460 tussocks)	covering about 3303 m ²
10	about 3 patches with 50-100 tussocks with most in one patch as seen in 2006 (J. Miskelly, pers. comm. 2008) but 6 patches documented in 2007 (J. Fenneman pers. comm. 2007)	scattered within an area of about 2.4 ha

Fluctuations and trends

Because *Carex tumulicola* was only discovered very recently in Canada, it is unclear whether the species has always been rare on southeastern Vancouver Island or whether it has undergone a recent dramatic decline. There is circumstantial evidence to suggest that populations at most sites have been largely displaced during the past century by the spread of trees and shrubs into formerly open meadow habitat, but this is difficult to confirm. There are currently insufficient data to estimate a % rate of decline for the total population, either for the past 10 years or over the last three generations. Long-term trends within populations (i.e., whether they are growing, declining, or stable) are also for the most part unknown.

The number of known *Carex tumulicola* populations in Canada has increased tenfold since the first collection was made in 1990 (Table 1). This increase can likely be ascribed entirely to increased search effort.

Rescue effect

The nearest populations of *Carex tumulicola* outside of Canada occur on San Juan Island, where it is found occasionally growing in moist meadows. San Juan Island lies less than 20 km from the nearest recorded population in Canada (Uplands Park), within easy flying range of birds. It is not known whether birds exploit the seeds of *C. tumulicola*, but it is possible that bird-aided seed interchange occurs between U.S. and Canadian populations on occasion. However, such dispersal events are likely to be extremely rare, if they occur at all.

Similarities in habitat suggest that plants from U.S. populations may be relatively well adapted to site conditions that prevail on southeastern Vancouver Island, so there is some potential for deliberate reintroduction should some or all Canadian populations become extirpated by events that do not reduce habitat suitability.

LIMITING FACTORS AND THREATS

Given our current limited understanding of *Carex tumulicola* habitat requirements and population dynamics, it is unclear what factors have contributed to its current restricted abundance and distribution in Canada. Its rarity may be the result of intrinsic factors such as low competitive ability, limited dispersal ability, high habitat specificity, or inherently low recruitment and survival; extrinsic factors such as geographic barriers or past climatic changes; recent land-use history (e.g., habitat conversion, grazing, fire suppression); or a combination of any or all of these. None of the seven threat factors identified below has been shown empirically to be responsible for declines (either current or historical) in the abundance or range of *C. tumulicola* within Canada. This may simply be because the species has not been monitored long enough in its native Canadian habitat for deleterious impacts stemming from such threats to be documented. In the absence of any direct evidence to the contrary, all threats are considered here to be clearly imminent but their impacts uncertain.

1. Invasive species encroachment

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

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

All ten extant populations of *Carex tumulicola* occur in habitats that have been severely degraded by the presence of invasive exotic plants. Exotic grasses (e.g., orchard grass (*Dactylis glomerata*), common velvet-grass (*Holcus lanatus*), barren brome (*Bromus sterilis*), sweet vernalgrass (*Anthoxanthum odoratum*), hedgehog dogtail grass (*Cynosurus echinatus*), and English ryegrass (*Lolium perenne*) dominate the herbaceous flora at most sites, with introduced shrubs comprising the main component of the understory at several locations. Although most intrusive where the ground has been disturbed, non-native species are also invading even relatively undisturbed sites. Scotch broom is the most widespread of the non-native shrubs, and also represents one of the most pernicious threats to *C. tumulicola* and its habitat. Introduced to the region as a garden ornamental in 1850, it has since become a dominant component of the plant community on eastern Vancouver Island. In many areas this leguminous shrub forms monospecific stands that have completely overtaken the native vegetation (Roemer 1972, Fuchs 2001). A nitrogen-fixer, Scotch broom has the potential to increase soil nitrogen levels, thereby changing the supply of this resource to the ecosystem (Parker and Haubensak 2004). It also generates large amounts of woody fuel that can support high intensity fires and in this way alter the natural disturbance regime. Gorse (*Ulex europaeus*) is another frequently associated shrub with similar life history characteristics and apparently similar destructive potential. Other introduced shrubs threatening to overgrow *C. tumulicola* at several sites include English hawthorn (*Crataegus monogyna*), Himalayan blackberry (*Rubus discolor*), English ivy (*Hedera helix*), and leather-leaved daphne (*Daphne laureola*).

As *Carex tumulicola* has been tracked for only a few years on Vancouver Island, it is difficult to assess quantitatively the impact of these invasions on either its distribution or population dynamics. The fact that *C. tumulicola* has managed to persist in highly invaded habitats until now, in some instances directly beneath the canopy of invasive shrubs, suggests that, once established, plants of this species can withstand a certain level of competition and overtopping. However, the very low ramet abundances observed at most sites suggest that recruitment is occurring rarely, if at all. It is likely that many of these small patches are relictual and will disappear once the current established individuals die.

Population #1

The municipal park that supports this population is a remnant Garry oak woodland-meadow-vernal pool complex located in a residential area within a few kms of downtown Victoria. Here, *Carex tumulicola* is restricted primarily to mesic microsites within the shrubby, snowberry (*Symphoricarpos albus*) dominated ecotone that separates the low-lying wet meadows in the middle of the park from the surrounding upland forest. English hawthorn (which in many places forms dense, monospecific stands), Scotch broom, gorse, leather-leaved daphne, and Himalayan blackberry are all prominent components of this zone (Collier *et al.* 2004). European ash (*Fraxinus excelsior*) is an introduced, exotic tree dominant in a 0.5 hectare section of the park close to the central meadow where the majority of *C. tumulicola* plants occur. In addition to several seed-producing trees approximately 70 years old, there are hundreds of saplings established in the surrounding meadows and extending up to 150 metres to the east and west of the mature trees. These saplings are expected to begin producing seed within fifteen years (Collier *et al.* 2004). Ash seedlings, which are usually found in areas of at least 80 percent herb/grass cover with less than 10 percent shrub cover, can reach densities of between 5 and 25 per m². If not controlled, this species will likely continue to spread into adjacent areas, competing with native vegetation for moisture, soil nutrients, and light (Collier *et al.* 2004).

Along with these aggressive woody species, introduced forbs such as field garlic (*Allium vineale*) and introduced perennial grasses such as orchard grass, sweet vernalgrass, Kentucky bluegrass (*Poa pratensis*), common velvet-grass, English ryegrass, creeping bentgrass (*Agrostis stolonifera*), and hedgehog dogtail grass have established in the same sites occupied by *Carex tumulicola*. Each of these grasses competes aggressively for water and nutrients and can form dense litter layers that block light and suppress the regeneration of native plants. Litter accumulation from these species also creates conditions for high-intensity fires (Garry Oak Ecosystems Recovery Team 2003). Orchard grass, which forms particularly extensive root systems and requires high nitrogen inputs, may pose the greatest imminent threat to *C. tumulicola* persistence. Originally introduced to coastal B.C. as a meadow forage crop, this species is still grown for hay and used in grass-seed mix to stabilize clearings and road cuts.

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

Population #2

This population is scattered across several different habitats including a remnant Garry oak meadow, a disturbed road verge, and a second growth grand fir (*Abies grandis*) forest. The meadow microsite is dominated by the invasive grass barren brome (*Bromus sterilis*), while the surrounding habitat is heavily invaded by Scotch broom. At the road verge site, *Carex tumulicola* competes on the margins of a Himalayan blackberry-snowberry thicket with Kentucky bluegrass, quackgrass (*Elymus repens*), redtop (*Agrostis gigantea*), orchard grass, and English ryegrass. However, the most tenuous localities appear to be those associated with the third habitat, where the four extant *C. tumulicola* tussocks are found along a metre-wide strip between a walking trail and a forest understory dominated by English ivy, an evergreen climbing vine that has infested most of this site. Two of these *C. tumulicola* tussocks, which were only first discovered in 2004 (Table 1), have already been largely overgrown by English ivy. Introduced to North America as an ornamental, English ivy is a significant invader on Vancouver Island throughout the Garry oak range and beyond. Ivy's dense growth and abundant leaves form a thick canopy just above the ground and prevent light from reaching other plants, crowding them out and preventing germination of their seeds. If left to spread, ivy can eventually exclude most plants on the forest floor (Garry Oak Ecosystems Recovery Team 2003). At the site in question, periodic mowing of the trailside appears to be the only factor preventing *C. tumulicola* from being completely overgrown by this species.

Population #3

This single patch also grows on the side of a footpath and is subject to mowing. It is partly overgrown by a stand of English hawthorn and native trembling aspen (*Populus tremuloides*). English hawthorn is an introduced ornamental plant, now widely naturalized in Garry oak and associated ecosystems. It replaces open grassland habitat with a dense shrub or small tree layer, dramatically altering the vertical structure and composition of the plant community. As noted above, this species has been ranked among the top ten invasive plants on Vancouver Island in terms of the significance of its impact on Garry oak and associated ecosystems (Murray 2004).

Populations #4-6

These populations all occur in disturbed meadows dominated by a suite of invasive grasses and forbs including Kentucky bluegrass, English ryegrass, redtop, and vetch. Much of the available *Carex tumulicola* habitat has become overgrown with either Scotch broom or gorse.

Population #7

A large English hawthorn bush grows next to the lone *Carex tumulicola* tussock at this site (A. Ceska, pers. comm. 2004).

Population #8

The shrub leather-leaved daphne now dominates the adjacent understory at this site and appears poised to overgrow the small opening where *Carex tumulicola* occurs. A relatively recent introduction to Vancouver Island, daphne has already become a major pest within Garry oak and associated ecosystems. It has the ability to replace native vegetation by producing a shrub layer where none existed before. Its dense canopy blocks light to the ground, eliminating herbaceous species and leaving the ground bare. Daphne is also thought to alter soil chemistry and acidity, thereby inhibiting the re-establishment of native plant species (Garry Oak Ecosystems Recovery Team 2003). As noted above, this species has been ranked among the top ten invasive plants on Vancouver Island in terms of the significance of its impact on Garry oak and associated ecosystems (Murray 2004).

Population #9

This site has Scotch broom that has been recently removed, but it is likely to regenerate. Other invasive species include common velvet grass, barren brome, hedgehog dogtail grass, smooth brome (*Bromus hordeaceus*) and orchard grass. All these species can impact *Carex tumulicola* by shading out or competing for spring moisture and thereby reducing the potential seed bed. Other subpopulations are threatened by cutleaf evergreen blackberry (*Rubus laciniatus*) or bull thistle (*Cirsium vulgare*).

Population #10

This population occurs in an abandoned pasture with a large component of invasive grasses and forbs.

2. Secondary succession due to altered fire regimes

Prior to European settlement of Vancouver Island, natural and human-initiated fires played an important role in the maintenance of the region's dry Douglas-fir forests and Garry oak savannahs (Turner and Bell 1971, Roemer 1972, MacDougall *et al.* 2004). While the average fire return interval in the Coastal Douglas-fir zone is estimated to be between 100 and 300 years (Agee 1993), First Nations tribes used frequent, low-intensity fires to maintain good hunting conditions and an open stand structure favourable to important staple foods such as camas (*Camassia* spp.) and other wild root crops (Turner 1999, Fuchs 2001). Regular burning slowed the succession of native shrubs (e.g., snowberry, Saskatoon (*Amelanchier alnifolia*), Nootka rose) and conifers such as Douglas-fir (*Pseudotsuga menziesii*), while ensuring a continuous supply of safe sites for the germination and establishment of herbaceous meadow plants. First Nations fire management practices may have also played an important role in the development and fertility of soils, by ensuring the steady release of organic nutrients into the upper soil horizon. Over the last 150 years, fire suppression has led to encroachment of woody shrubs and Douglas-fir into many formerly open

areas, dramatically altering community composition and structure (Fuchs 2001, Lea 2002, MacDougall *et al.* 2004).

Population #1

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

Population #2

The municipal park that supports locality #2f, like the one supporting Population #1, has had a long history of fire suppression. The single tussock at this site occurs in an opening surrounded by thick stands of snowberry and Nootka rose. Locality #2a occurs at the edge of a remnant Garry oak meadow in a microsite largely overgrown by various shrubs including snowberry. The other localities occur in a heavily shaded second growth Douglas-fir-grand fir (*Abies grandis*) forest that, before European settlement, likely also had the character of a more open woodland (Lea 2002). Snowberry, and introduced English ivy are now the major understory components at this site.

Populations #4-6 and #9

The coastal headland that supports these populations has undergone extensive forest and shrub encroachment since European settlement. Shrub thickets occur adjacent to several of the *Carex tumulicola* patches, and thatch buildup is heavy at most localities, with unknown consequences for *C. tumulicola* germination as well as for soil structure, microclimate, and nutrient cycles.

Population #8

The vegetation history of this site is unclear. Currently a mixed conifer-arbutus-Garry oak forest, in pre-settlement times it presumably was also maintained in a more open state by periodic fires. In the winter of 2004, an ice storm knocked down several Douglas-fir saplings that had established in the small opening containing *Carex tumulicola*, causing them to land directly on top of the (then dormant) *C. tumulicola*

patch. Only by sheer happenstance was this fact discovered, allowing the trees to be removed before any lasting damage to the site or plants could occur. Such events demonstrate the need for diligence in monitoring rare plant populations, even in instances where the habitat has not undergone any obvious recent human modification.

3. Habitat conversion (urbanization)

Currently, only one of the extant *Carex tumulicola* sites, Population # 7 near Nanaimo, appears to be directly threatened by habitat conversion. However, extirpation of this population would be a significant loss, as it is the most northerly occurrence (by nearly 100 km) in the species' global range. Loss of this one population would also result in a 10-fold reduction in the species' Canadian Extent of Occurrence, from ~1,700km² to ~ 90 km². The site in question is a rocky upland meadow and seepage area on the outskirts of Nanaimo, and one of the last remaining tracks of undeveloped land within the Regional District of Nanaimo. In 2003, a Preliminary Layout Application (PLA) was filed for a proposed trailer park development on a section of this property. The application has since expired, although a new PLA could be filed by the landholder at any time (R. Lawrance, pers. comm. 2004). It is not known at present whether the proposed development would directly impact the only known extant *C. tumulicola* colony (A. Ceska, pers. comm. 2004). Regardless, residential development of this area would inevitably result in the elimination of potential survival and recovery habitat for the species.

4. All-terrain vehicle (ATV) traffic

At both sites #1 and #7, recreational all-terrain vehicle traffic has created deep and lasting ruts through vernal pools, swales and meadows. At the latter site, this activity has also resulted in extensive erosion of the thin topsoil in sloping upland areas (Donovan 2004, C. Thirkill, pers. comm. 2004). Despite efforts of the landowner to block trail access with boulder placements and ditches, recreational users of all-terrain vehicles, 4x4s and (to a lesser extent) dirt bikes continue to access the area on a regular basis (C. Thirkill, pers. comm. 2004). In addition to altering the local hydrologic regime, off-roading has disturbed and compacted the soil, facilitated the spread of invasive species, and directly endangered the survival of at least one nationally endangered plant, bog birds-foot trefoil (*Lotus pinnatus*), through crushing (Donovan 2004). In the case of *Carex tumulicola*, even one carelessly laid vehicle track could do irreparable damage to the extant population.

5. Hydrologic alterations

Hydrologic alterations caused by development, deforestation, ditching, draining, paving, off road traffic, and agriculture can affect adjacent ecosystems through changes to the water table, increased annual runoff, frequency and duration of flood events, and disruption of surface and groundwater drainage patterns (Ward *et al.* 1998).

Population #1

This site has had an extensive history of draining and ditching dating back over a century, with major consequences for the vegetation communities in the park (Collier *et al.* 2004). Most of the early water diversions were carried out to improve pasture for grazing, but constructed drainage systems for roads and residential properties adjacent to the park have also had permanent impacts on the local hydrologic regime (Collier *et al.* 2004). A busy suburban thoroughfare bisects the park near its eastern end, effectively splitting the park in two. In past years, the municipality has deposited gravel in low-lying vernal swale areas in an attempt to repair tire ruts left by maintenance vehicles. There have also been calls from some area residents for increased ditching to reduce the amount of standing water on walking trails (R. Collier, pers. comm. 2004).

Population #3

This population occurs on the margins of Rithet's Bog, a remnant wetland area that in the past 110 years has been grazed, ditched and drained for agricultural use. At one time, the bog's fate was nearly sealed by the proposed development of a golf course. Wetland draining, combined with fire suppression, has allowed shrub thickets (e.g., willow, red-osier dogwood) to invade to the centre of the 38-hectare wetland, further altering its hydrology. More recently, urban development immediately adjacent to the bog has caused fluctuations in the supply of water flowing through it (Golinski 1996).

The site where *Carex tumulicola* grows is presently dominated by English hawthorn and trembling aspen (*Populus tremuloides*), a species not generally associated with *C. tumulicola* habitat. It is possible that *C. tumulicola* was once more widespread at this site but has since been crowded out by the increasing canopy cover around the margins of the bog. As forest succession proceeds, it is expected that most of the remaining *C. tumulicola* habitat will disappear, placing the current population at immediate risk of extirpation and possibly preventing its future recovery at the site.

Wetland restoration work on Rithet's Bog was initiated in 2001, via a partnership established between Ducks Unlimited, Rithet's Bog Conservation Society, Fisheries and Oceans Canada (DFO), and the Municipality of Saanich. To date, however, there have been no initiatives specifically targeting the management of *Carex tumulicola* in its native habitat.

Population #7

This population is located at the end of a vernal seep. Any major change in the pattern of surface and subsurface water flow, as might follow from new residential development or from damage to the soil caused by all-terrain vehicle traffic, would presumably put this population at risk.

6. Trampling and mowing

Three *Carex tumulicola* populations (#1, 2, & 3) occur at the edges of well used walking trails where trampling could pose a threat to plant survival and/or growth. Foot and dog traffic is especially heavy in the park supporting Population #1 (Collier *et al.* 2004). Here, winter rains result in large pools forming in the middle of most trails, sometimes forcing pedestrians onto the trail margins where *C. tumulicola* occurs. During the summer, many of these same trail sides are mowed. Portions of populations #2, 3, 4, & 5 are also subject to mowing. The long-term impact of these mechanical disturbances on the population dynamics of *C. tumulicola* is unknown. On the one hand, mowing likely has the beneficial effect of reducing competition from invasive shrubs and alien invasive grasses. On the other hand, mowing during summer, when *C. tumulicola* normally flowers and sets seed, must inevitably result in lost reproductive opportunity for the species. *Carex tumulicola* populations may be less resilient to such demographic perturbations on Vancouver Island, where the species reaches its northern range limit, than has been generally noted elsewhere.

7. Bank slumping

The shoreline bank supporting subpopulation #1m is gradually being eroded by wave action, which has resulted in segments of the bank slumping away. If this process continues unabated at the current rate, much of the bank—including the part of it presently supporting *Carex tumulicola*—could disappear within the next few years, placing this subpopulation at imminent risk of extirpation.

SPECIAL SIGNIFICANCE OF THE SPECIES

A *Carex* sold commercially as an ornamental by some garden nurseries in the U.S., primarily in California, was originally thought to be the native west coast *Carex tumulicola*. It is now known that the plants sold by nurseries as an ornamental and as a cover plant in ecological restoration projects in both Washington and Oregon are actually the European *Carex divulsa*, as determined by sedge specialist Dr. A. Reznicek (http://www.smgrowers.com/products/plants/plantdisplay.asp?plant_id=352). Within Canada, the species possesses no special significance with respect to the criteria established by COSEWIC, apart from the possibility, suggested by its disjunct distribution in northwestern North America, that it is a relict from the Hypsithermal Interval of warm, dry climate 4,000-6,000 years b.p. *Carex tumulicola* was listed by a nursery, with other species being tested, for possible use in creating the roof garden at the Vancouver Convention Centre Expansion project (Thuring 2007). It has subsequently been established that the cultivated samples being tested were likely nursery stock of the European *Carex divulsa* (Thuring, pers.comm. to E. Haber, 2008).

Aboriginal peoples in British Columbia have historically used sedges (“swamp hay”) as a traditional source of both fibre and fodder (Turner 1979). However, individual sedge species are generally not distinguished (Turner 1979), and there are no specific records of *Carex tumulicola* being utilized for this purpose either in Canada or the U.S.

EXISTING PROTECTION OR OTHER STATUS DESIGNATIONS

Carex tumulicola is not covered under CITES (Convention on International Trade in Endangered Species), the *Endangered Species Act* (USA) or the IUCN Red Data Book. Globally, it is ranked G4 (NatureServe 2005).

Carex tumulicola is red-listed and ranked S1 (critically imperiled) in British Columbia, the only Canadian jurisdiction where it occurs. The species can be added to the list of species for protection under the BC *Wildlife Amendment Act* (2004). In the U.S., it is ranked S1 in Idaho and SNR (unranked) in California, Oregon and Washington. Eight of the ten Canadian populations occur either in municipal parks or on DND or Parks Canada Agency land, thereby affording them some measure of effective protection over the short term. However, no specific management plans are in place to protect *C. tumulicola* at any of these sites.

TECHNICAL SUMMARY

Carex tumulicola

Foothill sedge

Carex tumulicola

Range of Occurrence in Canada :SW British Columbia

Demographic Information

Generation time (average age of parents in the population)	Perennial; unknown yrs
<i>Population trend and dynamics</i>	
Observed percentage of reduction in total number of mature individuals over the last 10 years.	Unknown
Projected percentage of reduction in total number of mature individuals over the next 10 years.	Unknown
Observed percentage reduction in total number of mature individuals over any 10-year period, over a time period including both the past and the future.	Unknown
Are the causes of the decline clearly reversible?	No
Are the causes of the decline clearly understood?	Unknown
Are the causes of the decline clearly ceased?	No
Observed trend in number of populations	Stable
Are there extreme fluctuations in number of mature individuals?	No
Are there extreme fluctuations in number of populations?	No

Number of mature individuals in each population

Population	N Mature Individuals
	Population #1: 40-70 tussocks Population #2: ~10 tussocks Population #3: 1 tussock Population #4: 50-100 tussocks Population #5: 100-500 tussocks Population #6: 50-200 tussocks Population #7: 1 tussock Population #8: 3 tussocks Population #9: 280-460 tussocks Population #10: 50-100 tussocks
Grand Total	585–1,445

Extent and Area Information

Estimated extent of occurrence (km ²) <i>(Estimate is based on recent survey and data from BC Conservation Data Centre, and represents roughly the area of the triangle formed by Nanaimo, Oak Bay, and Metchosin)</i>	~1,700 km ²
Observed trend in extent of occurrence Increased search effort since first discovery has shown the EO to be much more extensive but trends are unknown	Unknown
Are there extreme fluctuations in extent of occurrence?	No
Estimated area of occupancy (km ²) Actual area occupied (100 ha) is an estimate based on authors' tally of extent of habitat occupied by the 10 populations.	10 based on a 1x1 km square grid; 32 using a 2x2 grid km ²
Observed trend in area of occupancy As a consequence of search effort more sites are now known but these represent historically extant sites; actual trend in AO is unknown.	Unknown
Are there extreme fluctuations in area of occupancy?	No
Is the total population severely fragmented?	Yes
Number of current locations	10
Trend in number of locations Number of locations known has increased due to search effort but trend is unknown	Unknown
Are there extreme fluctuations in number of locations?	No
Observed trend in quality of habitat	Decline

Quantitative Analysis

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Threats (actual or imminent, to populations or habitats)

Actual threats but with degree of impact uncertain
<ol style="list-style-type: none"> 1. Invasive species encroachment – all 10 pops 2. Fire suppression – pops. 1, 2, 4-6, 9 3. Habitat conversion (agriculture, urbanization, residential development) – pop. 7 4. Off-road vehicles – pops. 1, 7 5. Hydrologic alterations – pops. 1, 3, 7 6. Trampling and mowing – pops. 1, 2, 3 7. Loss of habitat due to bank slumping – subpop. 1m (due to wave action)

Rescue Effect (immigration from an outside source)

Status of outside population(s) USA: apparently secure in WA, OR and CA; reported to occur in ID (S1), but this report likely erroneous	
Is immigration known or possible?	Unknown
Would immigrants be adapted to survive in Canada?	Likely
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	Unlikely

Current Status

COSEWIC: Endangered 2008

Status and Reasons for Designation

Status: Endangered	Alpha-numeric code: B1ab(iii)+2ab(iii)
Reasons for Designation: This perennial species is known from 10 localized and highly fragmented sites in southwestern British Columbia where it occurs in meadows and shrub thickets within Garry oak ecosystems, a critically imperiled habitat in Canada. The total Canadian population likely consists of fewer than 1000 mature individuals. Factors such as competition and habitat degradation from invasive alien plants, altered fire regimes, urbanization, trampling and mowing place the species at risk.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. No declines documented.
Criterion B (Small Distribution Range and Decline or Fluctuation): Endangered B1ab(iii)+2ab(iii). Meets criteria for EO and AO with the 10 populations being highly fragmented and decline in habitat quality is inferred based on a number of threats.
Criterion C (Small and Declining Number of Mature Individuals): Threatened C2a(i). The total population is <10,000 tussocks (plants) and no population is estimated to contain > 1,000 mature individuals
Criterion D (Very Small Population or Restricted Distribution): Threatened D1+2. Meets D1 since the actual population size is likely <1,000 mature plants, and meets D2 if the AO is based on a 1x1 km grid.
Criterion E (Quantitative Analysis): None available

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AUTHORITIES CONSULTED

- Eberhardt, E. February 2003. SAR Conservation Biologist / Data Mngt., Parks Canada National Office.
- Fraser, D. July 2004. Species Specialist, Species at Risk, B.C. Ministry of Water, Land and Air Protection. PO BOX 9338 Stn Prov Govt, Victoria BC V8W9M1.
- Goulet, G. March 2005. Coordinator, Aboriginal Traditional Knowledge, COSEWIC Secretariat, Canadian Wildlife Service, Environment Canada, Ottawa ON K1A 0H3.
- Penny, J. July 2004. Botanist, Conservation Data Centre, British Columbia Ministry of Sustainable Resource Management, PO BOX 9358 Stn Prov Govt, Victoria BC V8T 5K7.
- Robinson, A. July 2004. Federal Lands Forester, DND Environmental Science Advisory Committee, Pacific Forestry Centre, 506 West Burnside Road, Victoria B.C. V8Z 1M5

INFORMATION SOURCES

- Agee, J.K. 1993. Fire Ecology of Pacific Northwest forests. Island Press, Washington, D.C.
- Ball, P. 2002. *Carex* section *Phaestoglochin*. Pages 285-298 *In: Flora of North America Editorial Committee, (eds.) Flora of North America. Vol. 23: Magnoliophyta: Commelinidae (in part): Cyperaceae.* Oxford University Press, New York. 606 pp.
- B.C. Conservation Data Centre of British Columbia. 2004. HERB database. British Columbia Ministry of Sustainable Resource Management, Terrestrial Information Branch, Victoria, BC.
- Bergelson, J. 1990. Life after death: site pre-emption by the remains of *Poa annua*. *Ecology* 71: 2157-2165.
- Booth, W.E. 1950. Flora of Montana. Part I. Conifers and monocots. Montana State College, Bozeman, MT.
- Brown, C.S. and K.J. Rice. 2000. The mark of Zorro: effects of the exotic annual grass *Vulpia myuros* on California native perennial grasses. *Restoration Ecology* 8:10-17.

- Ceska, A. 2000. *Carex tumulicola* – an overlooked sedge in British Columbia. Botanical Electronic News No. 252. Web site: <http://www.ou.edu/cas/botany-micro/ben/ben252.html> [Accessed January 10, 2004]
- Ceska, A. pers. comm. 2004. *Email correspondence to M. Miller*. July, 2004. Botanist, Ceska Geobotanical Consulting, Victoria, BC.
- Chappell, C. and F. Caplow. 2004. Site characteristics of golden paintbrush populations. Washington Natural Heritage Program Department of Natural Resources, Olympia, Washington. 52 pp.
- Collier, R. pers. comm. 2004. *Verbal communication to M. Miller*. July, 2004. Environmental Consultant, Victoria, BC.
- Collier, R., F. Spencer and J. Miskelly. 2004. Uplands Park Stewardship Plan. Unpublished report to Parks and Recreation Commission, Municipality of Oak Bay. 70 pp.
- COSEWIC. 2005. Instructions for the preparation of COSEWIC status reports. Web site: http://www.cosewic.gc.ca/pdf/english/instructions_2005_e.pdf [Accessed: March 10 2005].
- D'Antonio, C.M and P.M. Vitousek. 1992. Biological invasions by exotic grasses, the grass/fire cycle, and global change. *Annual Review of Ecology and Systematics* 23:63-87.
- Douglas, G.W. D. Meidinger, and J. Pojar. 2001. Illustrated Flora of British Columbia. Vol. 6: Monocotyledons (Acoraceae through Najadaceae). B.C. Ministry of Environment, Lands and Parks, BC Ministry of Forests, Victoria BC. 361 pp.
- Eng, M. 1992. Protected areas on Vancouver Island: an analysis of gaps in representation for conservation purposes. Ministry of Forests, 1991/1992 Progress report. Victoria BC.
- Erickson, W.R. 1996. Classification and interpretation of Garry oak (*Quercus garryana*) plant communities and ecosystems in southwestern British Columbia. M.Sc. Thesis, University of Victoria, Victoria, BC.
- Facelli, J.M. and S.T.A. Pickett. 1991. Plant litter: it's dynamics and effects on plant community structure. *Botanical Review* 57:1-32.
- Fairbarns, M., B. Costanzo, and A. Ceska. 2003. COSEWIC status report on Dense Spike Primrose (*Epilobium densiflorum*). Report under review.
- Fenneman, J. pers.comm. 2007. Email correspondence (fennj@hotmail.com) to Jenifer Penny (BC Conservation Data Centre) on 7 Aug. 2007 providing site data for 6 tussocks of *Carex tumulicola* found on Sidney Island, 3 Aug. 2007.
- Fuchs, Marilyn A. 2001. Towards a recovery strategy for Garry oak and associated ecosystems in Canada: ecological assessment and literature review. Technical Report GBEI/EC-00-030. Environment Canada, Canadian Wildlife Service, Pacific and Yukon Region.
- Garry Oak Ecosystems Recovery Team. 2003. Invasive Species in Garry Oak and Associated Ecosystems in British Columbia. Garry Oak Ecosystems Recovery Team, Victoria, BC.
- Golinski, G.K. 1996. An environmental overview of Rithet's Bog. Report prepared for the Corporation of the District of Saanich.
- Gordon, D.R. Effects of invasive, non-indigenous plant species on ecosystem processes: lessons from Florida. *Ecological Applications* 8:975-989.

- Hitchcock, C.L., A. Cronquist, M. Owenby, and J.W. Thompson. 1969. Vascular Plants of the Pacific Northwest. Part 1. University of Washington Press, Seattle, WA. 914 pp.
- Holt, M.M. and A.G. van der Valt. 2002. The potential role of ducks in wetland dispersal. *Wetlands* 22:170-178.
- Idaho Fish and Game. 2004. Idaho Fish and Game information. Website: <http://www2.state.id.us/fishgame/info/cdc/plant.htm> [Accessed March 24, 2004].
- Jepson Herbarium. 1993. Jepson horticultural database. Web site: http://ucjeps.berkeley.edu/cgi-bin/get_hort.pl?taxon=Carex%20tumulicola [Accessed: March 11, 2004]
- Jungen, J.R., P.T. Sanborn, P.J. Christie. Soils of southeast Vancouver Island: Duncan – Nanaimo area. B.C. Ministry of Environment, Victoria. 188 pp.
- Lawrance, R. pers.comm. 2004. *Verbal communication to M. Miller*. November, 2004. Environmental Planner, City of Nanaimo.
- Lea, T. 2002. Historical Garry oak ecosystems of Greater Victoria and Saanich Peninsula. 1:20,000 Map. Terrestrial Information Branch, BC Ministry of Sustainable Resource Management, Victoria BC.
- Lesica, P. and F.W. Allendorf. 1995. When are peripheral populations valuable for conservation? *Conservation Biology* 9 (4): 753-760.
- MacDougall, A. 2002. Fine-scale fire effects in *Quercus garryana* grassland in P.J. Burton, (ed.) Garry Oak Ecosystem Restoration: Progress and Prognosis: Proceedings of the Third Annual Meeting of the B.C. Chapter of the Society for Ecological Restoration, April 27-28, 2002, University of Victoria. British Columbia Chapter of the Society for Ecological Restoration, Victoria, BC.
- MacDougall, A.S., B.R. Beckwith and C.Y. Maslovat. 2004. Defining conservation strategies with historical perspectives: a case study from a degraded oak grassland ecosystem. *Conservation Biology* 18: 455-465.
- Mastroggiuseppe, J. 1993. *Carex*. In J. Hickman, (ed.). The Jepson Manual: Higher Plants of California. University of California Press. Berkeley. 1400 pp.
- McMinn, R.G., S. Eis, H.E. Hirvonen, E.T. Oswald, and J.P. Senyk. 1976. Native vegetation in British Columbia's Capital Region. Report BC-X-140. Canadian Forestry Service, Pacific Forest Research Centre, Victoria, BC.
- Miskelly, J. pers. comm. 2008. Information provided by James Miskelly, based on observations made in July 2006, to Matt Fairbarns (Fairbarns email: aruncus_consulting@yahoo.ca) in Jan 2008 and subsequently provided to E. Haber by email correspondence (29 Jan. 2008) for incorporation into report.
- Murray, C. 2004. Decision support tool for managing invasive species in Garry oak and associated ecosystems in BC. Prepared by ESSA Technologies Ltd., Victoria BC, for the GOERT Invasive Species Steering Committee, Victoria.
- Myers, J.H. and D. Bazely. 2003. Ecology and Control of Introduced Plants. Cambridge University Press, Cambridge.
- NatureServe. 2005. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.3. NatureServe, Arlington, Virginia. Available <http://www.natureserve.org/explorer>. (Accessed: March 10, 2005).

- Nariyasu, W. N. Aya, and S. Kazuo. 2001. Seed banks in pastures: special reference to a persistent soil seed bank of invading species *Carex albata* Boott. *Grassland Science* 47:337-343.
- Newhouse, B. pers. comm. 2001. *Email correspondence to M. Fairbarns*. August, 2001. Oregon *Carex* Working Group, Oregon Natural Heritage Program.
- Parker, I.M. and K. Haubensak. 2004. Soil changes accompanying invasion of the exotic shrub *Cytisus scoparius* in glacial outwash prairies of western Washington. *Plant Ecology* 175:71-79.
- Peck, M.E. 1961. *A Manual of the Higher Plants of Oregon*. Binfords & Mort, Portland.
- Roemer, H.L. 1972. Forest vegetation and environments on the Saanich Peninsula, Vancouver Island. Ph.D. Dissertation, Univ. of Victoria, Victoria, BC.
- Roemer, H. 1995. Identity crisis: do we really know what we want to rehabilitate? *Botanical Electronic News* 105.
- Smith, J.M.B. 1994. The changing ecological impact of broom (*Cytisus scoparius*) at Barrington Tops, New South Wales. *Plant Protection Quarterly* 9: 6-11.
- Thirkill, C. pers. comm. 2004. *Email correspondence to M. Miller*. November, 2004. Local naturalist, Nanaimo, BC.
- Thuring, C. 2007. Green roofs are growing up. *Menziesia* 12(2): 1, 4-8.
- Thuring, C. pers. comm. 2008. Email correspondence from Christine Thuring, editor of Greenroofs.com web site, to E. Haber regarding the identity and possible use of the sedge being tested as part of a roof garden project at the Vancouver Convention Centre Expansion project (28 January 2008).
- Turner, N.C. and M.A.M. Bell. 1971. The ethnobotany of the Coast Salish Indians of Vancouver Island. *Economic Botany* 25:63-99.
- Turner, N. 1979. Plants in British Columbia Indian technology. Handbook no. 38, British Columbia Provincial Museum, Victoria B.C. 304 pp.
- Turner, N.J. 1999. "Time to burn:" traditional use of fire to enhance resource production by Aboriginal Peoples in British Columbia. Pp. 185-218 in R. Boyd, (ed.) *Indians, fire and the land in the Pacific Northwest*. Oregon State Univ. Press, Corvallis, OR.
- Vellend, M., M.J. Lechowicz, and J.M. Waterway. 2000. Germination and establishment of forest sedges (*Carex*, Cyperaceae): tests for home-site advantage and effects of leaf litter. *American Journal of Botany* 87:1517-1525.
- Ward, P., G. Radcliffe, J. Kirkby, J. Illingworth and C. Cadrin. 1998. Sensitive ecosystems inventory: east Vancouver Island and Gulf Islands, 1993 - 1997. Vol. 1: methodology, ecological descriptions and results. Technical Report Series No. 320, Canadian Wildlife Service, Pacific and Yukon Region, British Columbia.
- Wilson, M. 1999. Evaluating prescribed burning to improve prairie quality in the Willamette Floodplain Research Natural Area, W.L. Finley National Wildlife Refuge, Oregon. Special Report submitted to U.S Fish and Wildlife Service, Western Oregon Refuge Complex.
- Zika, P. pers. comm. 2004. *Email correspondence to M. Fairbarns*. January, 2004. Oregon *Carex* Working Group, Oregon Natural Heritage Program.

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Matt Fairbarns holds 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.

Sharon Hartwell holds a B.SC. in Botany from the University of Calgary (1976). She has conducted vegetation inventories for Parks Canada, and has worked since 1992 with the B.C. Conservation Data Centre, where she is an Assistant Botanist. She has also been closely involved with the restoration work at Rithet's Bog Conservation Area, in Victoria.

COLLECTIONS EXAMINED

The following collections were consulted:

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

The following databases were consulted:

- HERB: the rare plant records database of the British Columbia Conservation Data Centre
- Oregon Natural Heritage Program Database
- Idaho Conservation Data Center Database