



Site Characteristics of Golden Paintbrush Populations

Prepared for USFWS, Region 1

Prepared by
Chris Chappell and Florence Caplow

December 2004



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Chris Chappell
Florence Caplow
Washington Natural Heritage Program
Department of Natural Resources
Olympia, Washington
December 2004

Prepared for the U.S. Fish and Wildlife Service
through Endangered Species Act Section 6 funding
Grant Agreement E-2, Segment 35

EXECUTIVE SUMMARY

The Recovery Plan for the golden paintbrush, *Castilleja levisecta*, (USFWS 2000) stated that a high priority is the identification and clarification of site characteristics that are essential for golden paintbrush, both for management and reintroduction.

Region 1 of the U.S. Fish and Wildlife Service funded the Washington Natural Heritage Program (WNHP) to develop a list of site characteristics for the known sites for *Castilleja levisecta*. This work included soil sample collection for soils analysis, site visits, consultation of published soils and geologic data, and plant community characterization. This report summarizes the site characteristics of the known populations of *Castilleja levisecta*.

The vegetation associated with *Castilleja levisecta* is dominated by a mixture of graminoids and forbs. Shrubs are usually present in small amounts, and trees are rarely present. When moss is prominent the dominant species is usually if not exclusively *Dicranum scoparium*. *Festuca roemerii* was found only at the south Puget Sound site and was not even present in small amounts at any other site. We do not recommend planting *Festuca roemerii* on the northern Puget sites. Forbs dominate the vegetation at the two least disturbed northern sites and at some of the others also. We speculate that the pre-settlement vegetation on the mesic coastal prairies of Whidbey and San Juan that now support *Castilleja levisecta* was historically dominated primarily by forbs, with graminoids such as *Carex tumulicola* as a significant secondary component.

There is a wide range of soils and physical characteristics, but nearly all of the soils are well drained. From the soils analysis, in general, organic matter is very high, phosphorus is low to very low, magnesium is high to very high, calcium is low to very low, pH is acidic, iron is very high, copper is very low, soluble salts are low, percent sand is high, percent clay is low. Most sites lack significant gravel.

For reintroduction sites, we would recommend matching substrate and aspect to the closest known population. Even small changes of aspect on steep slopes may create conditions that are not favorable for *Castilleja levisecta*. We would suggest developing planting lists from species known from known populations of *C. levisecta* within the same geographic area as the reintroduction site.

Acknowledgements: We would like to acknowledge the assistance of Hans Roemer, Beth Lawrence, Christina Kellum, Matthew Fairbarns, George Douglas, Adolf Ceska, Mark Sheehan, Peter Dunwiddie, Terry Domico, land-owners who allowed access to their land, the Washington Natural Areas Program, and the Whidbey Naval Air Base. We would also like to thank Beth Lawrence for the use of the Trial Island soil data, and Matthew Fairbarns for collecting soil on Trial Island.

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1. INTRODUCTION

Golden paintbrush (*Castilleja levisecta*) is listed as threatened under the U.S. Endangered Species Act (ESA). The recovery plan for the species (USFWS 2000) stated that the identification of the physical and ecological characteristics of all known populations is essential for management and reintroduction of golden paintbrush. The reintroduction plan for golden paintbrush (Caplow 2004) reiterated the importance of identifying the site characteristics at the known sites for golden paintbrush, as a critical first step in the identification of potential reintroduction sites. Reintroduction efforts for other species have found that reintroduction is more successful if new sites match existing sites for a species as closely as possible (Heunneke *et al.* 1986). The site characteristics deemed most important in the reintroduction plan for golden paintbrush were geology, soils, topography, aspect, hydrology, plant community type, and range of microhabitats (Caplow 2004). Since the publication of the reintroduction plan, it has become apparent that lists of associated species from less degraded sites can also be used to develop appropriate planting lists for restoration of poor-quality sites.

Region 1 of the U.S. Fish and Wildlife Service, through Section 6 of the ESA, provided funding to the Washington Natural Heritage Program (WNHP) to develop a list of site characteristics for the known sites for *Castilleja levisecta*. This work included soil sample collection for soils analysis, site visits, published soils and geologic data, and plant community characterization. In some cases, one or more of these analyses were not completed, due to legal considerations (for instance, the difficulty of transporting soil across the US/Canadian border), or concerns of private property owners. This report summarizes the site characteristics of the known populations of *Castilleja levisecta*.

There are eleven known sites for *Castilleja levisecta*: nine in Washington and two in British Columbia (Figure 1 and Table 1). All eleven sites have been visited by one or both of the investigators in the course of this study. Earlier genetic work (Godt *et al.* 2003) identified three major genetic/geographical groupings of the populations of golden paintbrush. For the purposes of this report, we identify these as South Puget Sound (1 site), Whidbey Island (5 sites), and Northern Islands (3 sites in the San Juan Islands and 2 small islands in British Columbia). The Forbes Point population had genetic affinities with the Northern Islands group, but was included in the Whidbey Island group for the purposes of this report. We recommend that restoration decisions and reintroduction site selection within each area be restricted to data from that area (*e.g.*, if one is planning a reintroduction on Whidbey Island, the most appropriate sites would be ones that match the characteristics of one or more of the Whidbey Island populations, not the characteristics of the South Puget Sound population).

Site Characteristics of Golden Paintbrush Populations

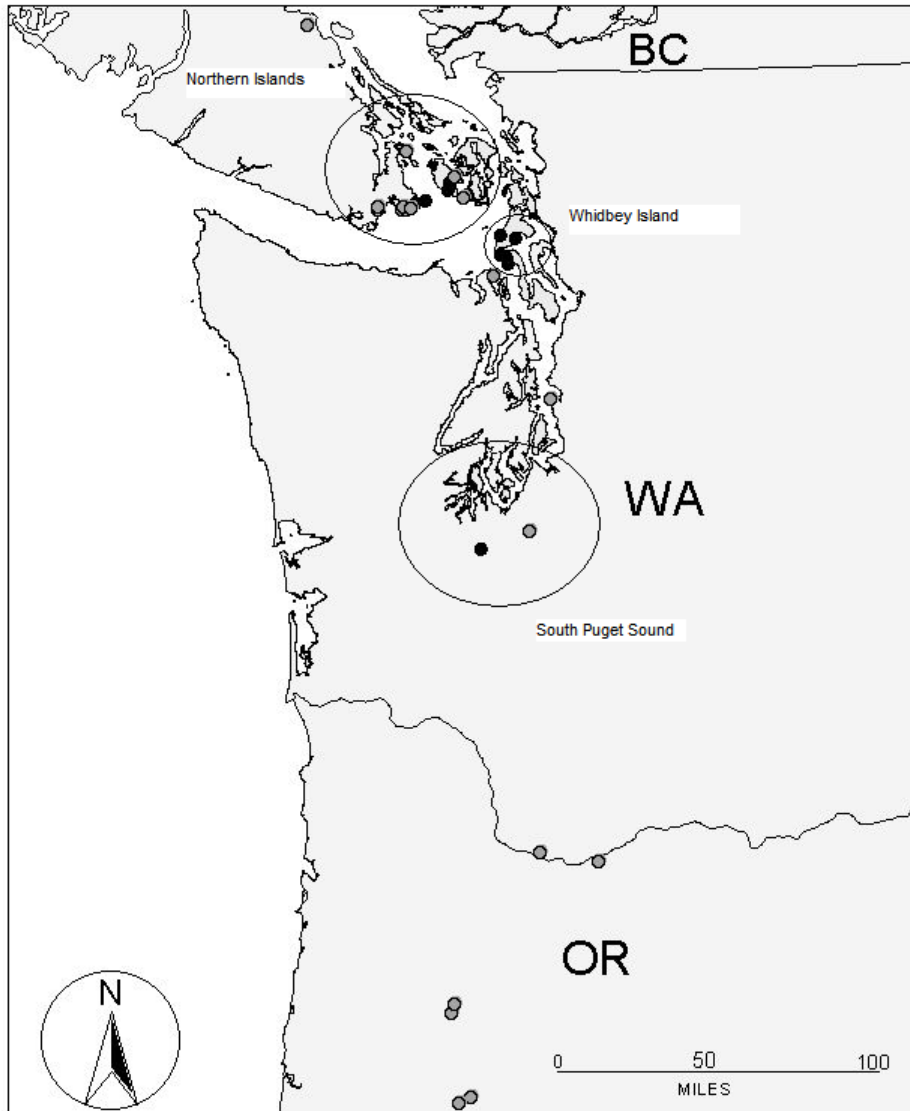


Figure 1. Golden paintbrush populations, historic and present. Gray circles are historic collection sites, black circles are extant populations.

Table 1. Summary of extant sites for *Castilleja levisecta*

Area	Site Name	County (if In Wash.) / B.C.	Size of Flowering Population (year)		Area	10-Year Trend
South Puget Sound	Rocky Prairie	Thurston	5,493	(2002)	16 ha	Stable?
Whidbey Island	Fort Casey State Park	Island	235	(2004)	4 ha	Unknown
	Ebey's Landing	Island	7,627	(2000)	0.5 ha	Stable?
	Bocker Environ. Reserve	Island	59	(2004)	0.5 ha	Declining
	Forbes Point	Island	532	(2004)	0.5 ha	Declining
	West Beach	Island	82	(2004)	0.5 ha	Declining
Northern Islands	Long Island	San Juan	154	(2002)	0.5 ha	Unknown
	False Bay	San Juan	247	(2004)	0.25 ha	Unknown
	San Juan Valley	San Juan	7,528	(2003)	1 ha	Increasing
	Alpha Islet	Brit. Columbia	800	(2002)	<0.5 ha	Stable
	Trial Island	Brit. Columbia	2,150	(2002)	3 ha	Stable

2. METHODS

2.1. Vegetation

Extant sites for *Castilleja levisecta* were sampled for their vegetation composition between May 5 and May 27, 2004. The timing of most sampling was between May 20 and May 27, a period during this year when phenology was optimal for observing and identifying both most graminoids (except *Agrostis* spp.) and a high diversity and cover of native forbs. The sampling on Trial and Alpha islands occurred on May 5, a time when some graminoids were not well expressed yet in the vegetation. A total of 10 sites were visited and a total of 20 macroplots were sampled. Two privately owned sites where the species is known to occur were not sampled: San Juan Valley and Long Island.

Each macroplot was a 25m² square (or rarely rectangle) subjectively placed to represent an area of typical vegetation where *Castilleja levisecta* density was relatively high for each site. *Castilleja levisecta* density varied greatly among the sites. If there were multiple relatively distinct vegetation types, an attempt was made to sample each type, even if one or more of the types had a lower density of *Castilleja levisecta* than others. Plots were usually placed in areas of relatively homogeneous vegetation.

Crown cover (in percent) was estimated and recorded for each vascular plant species present. Crown cover is the vertical projection of each plant's crown over the ground, including spaces between leaves. Cover was estimated as "trace" when below 0.5%, to the nearest 1% from 0.5% up to 15% cover, and to the nearest 5% from 15% to 100% cover. Cover of bare ground, rock (stones and bedrock including attached crustose lichens), lichen (except crustose on rocks), moss, total shrubs, total graminoids, and total forbs was similarly estimated. Aspect and slope were also recorded for each macroplot.

Vegetation data were summarized by site and by habitat type (Whidbey Island bluff, Whidbey Island coastal prairie, and shallow-soiled northern islands). For details, see Vegetation Tables 1 through 14 in Section 5.2.

Nomenclature in the text below follows that of Kartesz (2003). Because of apparent intergradation, the two varieties of *Sanicula crassicaulis* were not distinguished by percent cover, but are sometimes referred to at particular sites if we identified one or more of the varieties at a site. The *Festuca rubra* complex is notoriously variable and complex. Existing keys for distinguishing subspecific taxa are inadequate in this region because they rely too heavily on environmental factors (proximity to saltwater). Native taxa include *Festuca rubra* subspecies *arenaria*, *mediana*, *pruinosa*, and *secunda* (Kartesz 2003). Subspecies *rubra* is considered non-native and is widespread. While it seems reasonable to assume that the *Festuca rubra* occurring on coastal bluffs and other sites extremely close to saltwater is native in origin, *Festuca rubra* growing on disturbed coastal prairies somewhat near saltwater may or may not be native, and are likely to be non-native.

2.2. Soils

Soil samples were collected from within *Castilleja levisecta* populations at 8 U.S. sites in May of 2002. Depending on the size of the population and the heterogeneity of the site, we collected one to three samples at each site. We took samples in the following way: a 1 X 1 m area was subjectively chosen within the population (but in a place that did not directly support *Castilleja levisecta*, to avoid damaging plants). Five small holes were dug: one at each corner of the plot and one in the middle. We collected soil from approximately 30 cm below the soil surface from each of the holes with a trowel. Rocks and gravel were not sifted out of the sample, except at Rocky Prairie, where large rock were removed (C. Kellum, *in litt.*, 2004). We mixed the soil from within the 1 X 1 m area to produce a sample of approximately 500 cm³ of soil. The soil samples were sent to A & L Western Agricultural Laboratories in Modesto, California for analyses (see Table 1 in Section 5.3).

Soils samples were collected from Trial Island on April 21, 2004, using the same technique described above. Two samples at each of five sampling sites were collected (M. Fairbarns, *in litt.*, 2004). These were analyzed at Oregon State University. Two subsamples from each collection site were used to quantify soil chemistry. Organic matter content was calculated using the loss on ignition method. Soil texture (% sand, silt, & clay) was calculated using the hydrometer method. Other elemental analysis conducted using an "ICP OES" (Inductively Coupled Plasma Optical Emission Spectrometer), "Optima 4300 DV" (B. Lawrence, *in litt.*, 2004). Because different analysis methods were used for these samples, they should not be directly compared to the soils from the rest of the sites. Table 2 in Section 5.3 summarizes these analyses.

2.3. Physical characteristics

We collected data on aspect, slope, and topography in the field. County soil surveys (Ness and Richins 1958, Pringle 1990, Schlots et al. 1958) and the Coastal Zone Atlas (Youngmann 1977) were consulted for mapped geologic units and soil types.

3. SITE DESCRIPTIONS

3.1. South Puget Sound

The only South Puget Sound prairie site with *Castilleja levisecta* is Rocky Prairie. There were two historic collection sites from southern Puget Sound: at Roy in 1889 and “Tenino Prairie” (which may have been Rocky Prairie) in 1937. This area differs from the other extant areas within the golden paintbrush range by its much higher annual precipitation levels: 129 cm versus 43 to 72 cm in the other areas (Western Regional Climate Center 2004).

3.1.1. Rocky Prairie

General: Rocky Prairie is undulating to mounded, with a large swale running through the middle. Slopes range from flat to 35% on the mounds. *C. levisecta* occurs on all aspects and in patches throughout most of the 16-hectare site. This is one of the largest and most robust populations, with more than 5,000 individuals counted in 2002. This population is the only known extant population located more than 2 km from salt water.

Geology and Soils: Rocky Prairie formed on very deep, coarse textured, recessional glacial outwash from the Vashon glaciation, with an admixture of volcanic ash (Pringle 1990). The intermound areas are gravelly and the mounds are much less gravelly and have deeper A horizons. Rocky Prairie soils are mapped as Spanaway-Nisqually complex (Pringle 1990). This is the same mapped type as other South Sound prairie sites that have mounded topography, but there may be fewer coarse fragments than on other South Sound prairie sites, which might explain the predominance of the moss *Dicranum scoparium*. Rocky Prairie soils averaged nearly 80% sand, and had the lowest average pH of any of the sites (5.4). Unfortunately, we did not collect data on percent coarse fragments in the soil samples, and large rocks were sifted from the samples.

Vegetation: *Festuca roemerii* is dominant or co-dominant throughout the site. Other graminoids that have high constancy and are sometimes prominent in terms of cover include *Carex inops* ssp. *inops* and the non-native *Anthoxanthum odoratum*. *Agrostis* spp. (probably mostly *A. capillaris*, a non-native) also has high constancy but had not fully developed in terms of percent cover as of the sample date. It is likely to be consistently prominent. *Luzula multiflora* ssp. *multiflora* var. *multiflora* was consistently present in small amounts.

Leucanthemum vulgare, a non-native, and the fern *Pteridium aquilinum* var. *pubescens* are the most abundant non-graminoid herbaceous species, locally providing up to 20 percent cover. *Lupinus albicaulis* var. *albicaulis* is usually present and is prominent on the stands with the highest density of *Castilleja levisecta*. Other frequent forbs are the natives *Achillea millefolium* var. *occidentalis*, *Camassia quamash* var. *azurea*, *Eriophyllum lanatum* var. *lanatum*, *Fragaria virginiana* ssp. *platypetala*, *Hieracium cynoglossoides*, *Microseris laciniata* spp. *laciniata*, *Potentilla gracilis* var. *gracilis*, *Prunella vulgaris* ssp. *lanceolata*, *Ranunculus occidentalis* var. *occidentalis*, *Solidago canadensis* var. *salebrosa*, *Solidago missouriensis* var. *tolmieana*, and *Solidago simplex* ssp. *simplex* var. *simplex*, and the non-natives *Teesdalia nudicaulis*, *Hypericum perforatum*, and *Hypochaeris radicata*. *Symphoricarpos albus* occurs locally on the site and appears to be increasing. Moss cover is consistently high and is dominated by *Dicranum scoparium*. Lichen cover is low and shrubs and bare ground cover are absent on plots sampled at Rocky Prairie.

3.1.2. Discussion of Rocky Prairie

Rocky Prairie vegetation associated with *Castilleja levisecta* is similar enough to other existing South Sound prairies to be considered part of the *Festuca roemerii* – *Sericocarpus rigidus* (synonym: *Aster curtus*) association (Chappell and Crawford 1997, Chappell 2004, NatureServe 2004). However, it differs on average from most of the existing vegetation in this association in the following ways: (1) the moss layer is dominated by *Dicranum scoparium* as opposed to the more common (for this association) *Racomitrium canescens*; (2) *Lupinus albicaulis* is more frequent and abundant than on most sites; (3) overall species diversity is relatively high; (4) abundance of *Sericocarpus rigidus* is lower than typical; (5) *Cerastium arvense* spp. *strictum* is relatively consistent in occurrence whereas it is typically absent or inconsistent on other sites ; and (6) *Lomatium triternatum* is present and *Lomatium utriculatum* is absent. The soil texture appears to be generally less gravelly than most existing South Sound prairies, though data collection would be necessary to confirm this.

3.2. Whidbey Island

Whidbey Island has five extant sites of *Castilleja levisecta*, all on coastal bluffs or areas immediately upslope of coastal bluffs. Four sites are on the west side of Whidbey Island, and one is on the east side of the island. The three populations near Ft. Casey (Ft. Casey, Bocker, and Ebey's Bluff) could be considered one population, and may have been less fragmented in the past, but are currently mapped and considered three separate populations. There was also a historical site for *C. levisecta* in the Deception Pass area that was last seen in 1980. Island County historically supported large areas of coastal and non-coastal prairie. Annual precipitation is approximately 53 cm (Western Regional Climate Center 2004).

3.2.1. Ft. Casey

General: The population of *Castilleja levisecta* at Ft. Casey is scattered on the low, sandy bluffs and along the trails in a gently sloping area above the bluffs. The mean high tide line is approximately 35 m from the edge of the population, but the salt spray effect may be high at this site, due to the low height of the bluffs (less than 7 m in some places). This site was used by the military for much of the last century. Slopes range from 9% above the bluffs to 92% on the bluffs, and aspect ranges from 232° to 285° (SW to WNW). The population size has varied from 150 to 307 individuals in the last five years, scattered over 4 hectares.

Geology and Soils: Surficial geology mapping (Youngmann 1979) indicates that the Ft. Casey population occurs on soils formed in Vashon drift. These generalized glacial deposits associated with the Vashon glaciation are most often either: (1) thin or discontinuous till over advance outwash, or (2) thin recessional outwash or gravelly ablation deposits over till (Youngmann 1979). The mapped soil series is Hoypus loamy sand, derived from glacial outwash or morainal material (Ness and Richins 1958). In general, the bluffs are very sandy, while the grassland and shrubland above the bluffs has higher organic matter. Based on the soils analysis, Ft. Casey soils are sandy loams or loamy sands, and they have the highest levels of potassium, magnesium, sodium, and boron of any of the sites, which suggests that salt spray at this very exposed site may be significant in altering soil chemistry (R. Bigley, pers. comm. 2004).

Vegetation: The Fort Casey site has three distinctly different vegetation types: a relatively short coastal bluff, a gently sloping area formerly dominated by tall shrubs and recently mowed (mowed shrub habitat), and a gently sloping area dominated by forbs.

The Fort Casey bluff is dominated by native *Festuca rubra*. The non-native grass *Bromus hordeaceus* is prominent. The forb *Lomatium nudicaule* is prominent, as is the non-native *Plantago lanceolata*. *Achillea millefolium* and *Sanicula crassicaulis* are also quite abundant. This sandy bluff has no moss cover and about 10 percent cover of bare soil. This vegetation type is part of the *Festuca rubra*–(*Camassia leichtlinii*, *Grindelia stricta*) association (NatureServe 2004). It is fairly typical of sandy bluff variants of the association (which typically lack *Camassia*), though the presence and abundance of *Sanicula crassicaulis* and *Lupinus densiflorus* var. *densiflorus* is more than is usual for the type.

The Fort Casey mowed shrub habitat is a mixture of shrub and herbaceous vegetation with 35% cover of low-growing (because of mowing) shrubs, 35% cover of graminoids, and 20% cover of forbs and ferns. The most abundant species at 25% cover is the non-native grass *Holcus lanatus*. The shrubs *Rubus ursinus* var. *macropetalus* and *Symphoricarpos albus* var. *laevigatus* each occupy about 15% cover. The non-native grass *Dactylis glomerata*, and the forbs *Heracleum maximum* and *Sanicula crassicaulis* var. *crassicaulis* are also

quite abundant. Bare soil, mosses, and lichens are absent. This vegetation type does not correspond to a described plant association. It is transitional between herbaceous and shrub dominance and has a high abundance of non-native species because of the effects of shrub invasion onto former coastal prairie and subsequent mowing treatments.

The Fort Casey forb habitat is dominated by forbs with a significant mixture of graminoids and no shrubs. This habitat has been converted, through repeated mowing, from a shrub-dominated habitat to a forb habitat in the last seven years. The non-native *Plantago lanceolata* and the native *Lupinus densiflorus* co-dominate this habitat. The forb *Sanicula crassicaulis* (vars. *crassicaulis* and *tripartita*) and the non-natives *Vulpia bromoides*, *Poa pratensis*, and *Trifolium dubium* are prominent. Bare soil, shrubs, mosses and lichens are absent. This vegetation type does not correspond to any described plant association and has a relatively high abundance of non-native species.

3.2.2. Ebey's Bluff

General: The population of *Castilleja levisecta* at Ebey's Bluff is found on the upper portion of a steep, tall (30 m), unstable coastal bluff, 25 m from mean high tide. Slopes are more than 90%, and the aspect is 237° (southwest). The Ebey's Bluff population has been one of the largest populations of *C. levisecta*: during the last census in 2000 there were more than 7,600 individuals in an area less than an 0.5 hectare. A mid-summer fire in 2002 caused the mortality of a significant number of individuals, and the population is vulnerable to erosion, either catastrophic or more gradual.

Geology and Soils: Surficial geology maps indicate that the soils of the Ebey's Bluff population formed in Pleistocene sand deposits older than Vashon till (Youngmann 1979). These sands were deposited by pro-glacial or non-glacial streams. The mapped soil type is rough broken land (Ness and Richins 1958), a generalized category for steep or rocky areas unsuitable for cultivation. Based on the soils analysis, soils at Ebey's Bluff are sands and loamy sands (83% to 91% sand). Ebey's has the highest soil pH of any of the sites, and the lowest organic matter. Based on the levels of potassium, magnesium, sodium, and boron, Ebey's Bluff may be less influenced by salt spray than one might expect, perhaps because of the height of the bluffs.

Vegetation: The site is dominated by grasses, mostly *Festuca rubra* and the non-native *Bromus rigidus*. Other relatively abundant species are *Lupinus littoralis*, the shrub *Mahonia aquifolium*, *Plantago lanceolata*, *Rumex acetosella*, and *Cerastium arvense* ssp. *strictum*. Bare soil covers about 2 percent of this plot and moss covers 1 percent. This vegetation type is part of the *Festuca rubra* – (*Camassia leichtlinii*, *Grindelia stricta*) association (NatureServe 2004). It is fairly typical of sandy bluff variants of the association (which typically lack *Camassia*), but has a relatively high proportion of non-natives. *Erigeron speciosus* var. *speciosus* and *Lupinus littoralis* are not typical of this association.

The portion of the site sampled was relatively high in cover of native species (as well as density of *Castilleja levisecta*) in comparison to much of the site, which has higher cover of non-natives, especially the annual *Bromus rigidus*.

3.2.3. Bocker

General: The population at the Bocker site is on a flat, altered coastal prairie remnant within 40 meters of steep, 40 m high coastal bluffs, and approximately 100 m from the mean high tide line. This site once supported more than 2,700 individuals on approximately 2 hectares, but has declined to less than 100 individuals over about 0.5 hectare. The reasons for the decline are not obvious, but may include herbivory and competition from both native and non-native vegetation.

Geology and Soils: Surficial geology mapping shows the site as Vashon till (Youngmann 1979). Vashon till has a very compacted hardpan, and typically consists of poorly sorted sand, silt, and gravel. The mapped soil series is Hoypus coarse sandy loam (Ness and Richins 1958), which is derived from glacial outwash or morainal material, not till. Based on the soils analysis, the soil at Bocker is a sandy loam, with no gravel. The apparent lack of gravel at the site is inconsistent with a typical Vashon till. This inconsistency and the lack of agreement between the surficial geology map and the soil map raise some question as to the parent material at the site. If the soil is actually derived from glacial till, it may better fit the Townsend soil series, which supported pre-settlement prairie vegetation, or the Bozarth soil series, which has wind-blown sandy material without gravel on top of compact till (Ness and Richins 1958). Bocker has the lowest nitrogen of any site, and shows little sign of salt spray influence, despite its proximity to a coastal bluff.

Vegetation: The Bocker site is dominated by a mix of graminoids and forbs. *Carex tumulicola* and *Sanicula crassicaulis* (vars. *crassicaulis* and *tripartita*) are consistently prominent to co-dominant. *Solidago canadensis* var. *salebrosa*, *Dactylis glomerata* (non-native) and *Heracleum maximum* are locally co-dominant. The non-native herbs *Anthoxanthum odoratum*, *Poa pratensis*, *Agrostis* spp., *Holcus lanatus*, *Plantago lanceolata* and *Vicia sativa*, and the native shrubs *Rosa nutkana* and *Rubus ursinus* var. *macropetalus* are at least locally prominent. Mosses and lichens are absent. There is no bare ground on the site and relatively heavy continuous litter.

3.2.4. Forbes Point

General: The population of *Castilleja levisecta* at Forbes Point is on a nearly flat, altered coastal prairie remnant, within approximately 25 meters of a low, south-facing coastal bluff. The Forbes Point population is within a 0.5 hectare area within the prairie remnant. In 1985 the site supported a population of more than 2,000 individuals, but the last census in 2004 found only 532 individuals.

The decline may be due to a combination of herbivory (although the population is fenced to exclude larger herbivores) and competition from non-native grasses.

Geology and Soils: Surficial geology mapping identified the site as Everson glaciomarine drift (Youngmann 1979). This massive layer of pebbly silt was deposited by marine waters during the Everson Interstade of the Vashon glaciation. The soil is mapped as Coveland loam (Ness and Richins 1958). The Coveland series is described as being derived from glacial till and imperfectly drained. Based on the soils analysis, the soils at Forbes Point range from sandy loams to clay loam. Forbes Point was the only site to have a significant clay fraction (27% in one sample). Forbes Point had a relatively high nitrogen level and also showed signs of some salt spray influence. Given the variety of soil textures encountered during the soils analysis and the inconsistency between the surficial geology and soils maps, there is some question as to the actual parent material found on the site.

Vegetation: The Forbes Point site is a degraded coastal prairie remnant dominated by graminoids and a major forb component. The non-native grass *Poa pratensis* is consistently dominant to co-dominant. *Carex tumulicola* and *Festuca rubra* are locally co-dominant. *Plantago lanceolata*, *Sanicula crassicaulis*, and *Bromus carinatus* are prominent, and *Vicia villosa*, a non-native, is locally prominent. Moss cover averages 33% and shrubs have a low percent cover, although *Rosa nutkana* has been increasing over the past few years.

3.2.5. West Beach

General: The *Castilleja levisecta* population at West Beach is on a flat remnant coastal prairie, less than 30 m from a 12 m bluff (and approximately 80 m from the mean high tide line). The total area of remaining habitat is very small (less than 0.5 hectare). Although this site supported a population of more 1,200 individuals in 1996, the population has declined to less than 100 individuals in the last three years. Herbivory is likely the main cause of decline on this site, since the site is still not shrub-dominated and supports native grasses and forbs. This site is privately owned and not managed for *C. levisecta*.

Geology and soils: The surficial geology map shows the site right at the edge of Vashon till and Everson glaciomarine drift (Youngmann 1979). The mapped soil series is Bozarth fine sandy loam (Ness and Richins 1958). The Bozarth series is derived from wind-blown sandy material 20 inches thick on top of compact glacial till. Based on the soils analysis, the soils at West Beach are loamy sands (71% sand). The soils at West Beach showed some salt spray influence and were relatively low in organic matter, nitrogen, and pH. The soils analysis appears to be relatively consistent with the Bozarth soil series and surficial geology of Vashon till.

Vegetation: The West Beach stand is co-dominated by *Carex tumulicola* and *Festuca rubra*. *Fragaria virginiana* ssp. *platypetala*, *Plantago lanceolata*, *Anthoxanthum odoratum*, *Pteridium aquilinum* var. *pubescens*, and *Vicia hirsuta* are at least locally prominent. There is also an unusually large population of *Fritillaria lanceolata*. Mosses, lichens, and bare ground are absent and shrubs have low percent cover. Litter forms a continuous layer between the bases of plants.

3.2.6. Discussion of Whidbey Island sites

The *Castilleja levisecta* sites on Whidbey Island have a number of significant commonalities: all are close to salt water and to coastal bluffs (and several show signs of salt spray influence in the soil), all but one (Ebey's bluff) occur on a substrate of glacial deposits, all have fairly deep sandy or sandy loam soils without a gravelly component, and all lack *Festuca roemerii*. Four of the five have populations of *Carex tumulicola*.

The five macroplots taken from three coastal prairie remnant sites (Bocker, Forbes, and West Beach) on Whidbey Island have many environmental and floristic similarities. They do not correspond with described plant associations and we have not observed similar vegetation elsewhere. They differ significantly from Roemer's fescue dominated prairie remnants in the same northern Puget Trough region (see Chappell, in prep., *Festuca roemerii* – *Camassia quamash* – *Cerastium arvense*). Differences include (1) abundant *Festuca rubra*, *Carex tumulicola*, *Sanicula crassicaulis*, and *Solidago canadensis*; (2) absence of *Festuca roemerii*, *Camassia quamash*, *Zigadenus venenosus*, *Lomatium utriculatum*, and *Cerastium arvense*; and (3) different soils. Native herbaceous taxa with high constancy in the coastal prairie remnant plots are *Bromus carinatus*, *Luzula comosa*, *Carex tumulicola*, *Achillea millefolium*, *Sanicula crassicaulis*, and *Solidago canadensis*.

While these coastal prairie remnants have undoubtedly been significantly altered by past grazing, the extent of differences from Roemer's fescue prairie communities do not appear to be solely due to disturbance history. We would hypothesize that these coastal prairies, because of more mesic soils associated with the lack of surficial gravel and perhaps restrictive soil layers (and perhaps fog effects or other environmental factors), supported a unique assemblage of herbaceous plants. One approach for constructing a planting list for restoration would be to use all the natives that occur on any of the coastal prairie sites (Bocker, Forbes, and West Beach) for planting at equivalent, deep soiled, non-bluff Whidbey coastal prairie remnants (e.g. include *Castilleja miniata* even though it only occurs on one of the macroplots). The assumptions are that grazing and fire suppression have reduced the abundance or presence of many natives, and that the coastal prairies on Whidbey would have had similar vegetation.

All of the sites on Whidbey Island have been experiencing declines in the last five years, with the exception of Ft. Casey, which has been engaged in intensive habitat management and outplanting. The reasons for the declines are not obvious, but may be a result of a combination of intense herbivory (by deer, rabbits, and/or voles), thatch build-up, and competition from both native forbs and shrubs and non-native grasses. Eastern cottontail populations on the west side of Whidbey Island are at very high levels. Any reintroduction site on Whidbey Island is likely to face similar challenges, and will need intensive management to be viable.

3.3. Northern Islands

The Northern Islands area includes sites in the San Juan archipelago and sites on islands in British Columbia at the south-eastern tip of Vancouver Island. There are five *Castilleja levisecta* populations in this area: two on San Juan Island, one on a nearby small island (Long Island) and two on small islands in Canada. There are more than 13 historical sites for *C. levisecta* in this area, and most are on or near Vancouver Island. Average annual precipitation varies considerably within this area, but for one station on Orcas Island (near the center of the area), average annual precipitation was 71 cm (Western Regional Climate Center 2004).

3.3.1. Long Island

General: Long Island is an approximately 60-acre island mostly 20-60 feet in elevation above sea level, with short bluffs along much of its perimeter. Long Island is privately owned and access is limited. The last census of the *Castilleja levisecta* population was in 2002, and there were 164 individuals scattered on a portion of the island (T. Domico, pers. comm. 2002). The population is located on shallow soils in the vicinity of rock outcrops, and portions of the population are within 10 m of the mean high tide line. The slope is west- to west-northwest facing and moderate in steepness. The population is very close to a saltwater shoreline and probably well within salt spray influence.

Geology and Soils: The surficial geology map shows the site as Flysch-type rocks, which are a mixture of sandstone, shale, conglomerate, and chert that have not been accurately dated (Youngmann 1978). The island has areas of shallow soil over bedrock, as well as extensive deposits of gravelly sandy glacial outwash. The mapped soil is San Juan gravelly sandy loam (Schlots et al. 1958), which is a relatively deep glacial outwash soil. Though it is clear that the San Juan series does occur on the island, this soil type does not fit the *Castilleja levisecta* site well because of the rock outcrops and shallow soil. Based on the soils analysis, the soils within the *C. levisecta* population on Long Island are loamy sands and sandy loams. All three soil samples from Long Island had relatively high levels of organic matter, and two samples also had high nitrogen levels. Salt spray influence can be seen in the relatively high levels of sodium, boron, and magnesium.

Vegetation: No plot data were collected in the population, but they were collected elsewhere on the island, so the vegetation description is generalized. The vegetation is dominated or at least co-dominated by native *Festuca rubra*. Other native species that are both known to be present on the island and believed to be associated with the *Castilleja levisecta* include *Elymus glaucus*, *Camassia leichtlinii* ssp. *suksdorfii*, *Lomatium nudicaule*, *Ranunculus californicus*, *Brodiaea coronaria*, *Cerastium arvense* ssp. *strictum*, *Fritillaria affinis* var. *affinis*, and *Achillea millefolium*. The non-native grasses *Holcus lanatus*, *Poa pratensis*, and *Bromus hordaceus* are present and at least one of them, if not all three, is prominent to co-dominant in the area with the *Castilleja levisecta*. This vegetation type is typical of the *Festuca rubra* – (*Camassia leichtlinii*, *Grindelia stricta*) association where it occurs on shallow soils (NatureServe 2004).

3.3.2. False Bay

General: The False Bay population is actually three small subpopulations in the False Bay area of San Juan Island. All three are on private land and access is limited. One is now reduced to less than 10 individuals, and was included only in the soils portion of this study. The other two are approximately 0.5 km apart, and may have been more continuous in the past. The two subpopulations are quite different: subpopulation #1 is small (approximately 50 individuals in a 5 X 10 m area) on a low, west facing, rocky coastal bluff, within 5 m of the mean high tide line. The aspect is 275° (W) and the slope is 75%. Subpopulation #2 is also quite small (approximately 150 individuals in a 5 X 10 m area) but is in a flat clearing in an otherwise shrubby area near the edge of a second-growth forest. The aspect is 160° (SSE) and the slope is 4%. Subpopulation #2 is more than 250 m from salt water.

Geology and Soils: Surficial geology at both sites is mapped as Orcas Formation (Youngmann 1978). Orcas Formation consists of ribbon chert with minor interbeds of basaltic tuff, pillow lava, and scattered limestone beds. The soil at Subpop. #1 is mapped as Bow silt loam and at Subpop. #2 near the boundary of Roche-rock outcrop complex and Rock land (Schlots et al. 1958). Bow soils formed in fine-textured glacial till and glacial lake sediments. Roche soils formed in gravelly or stony glacial till. Rock land and Rock outcrop refer to shallow soils and numerous rock outcrops. There are rock outcrops present near the Subpop. #2 site and on the lower portion of the bluff at subpopulation #1. Based on the soils analysis, soils range from sandy clay loam (subpopulation #1) to loamy sand (subpopulation #2), and lack coarse fragments. Subpopulation #1 had significantly more magnesium, potassium, and sodium than subpopulation #2, probably because of its proximity to salt spray. Subpopulation #2, on the other hand, had relatively high levels of organic matter and nitrogen, and a relatively high pH. These results for Subpopulation #2 suggest that the site was historically grassland rather than forest. The soils analysis, surficial geology map, and soils map are not consistent with each other at either of the False Bay sites, so there is uncertainty as to the actual parent material of the soils.

Vegetation: Subpopulation #1 is a short coastal bluff with shrubland covering its upper more gradual portion. Grasses dominate the lower, steeper portion. The shrubland and grassland portions gradually transition into each other and the macroplot included both an area of shrubland and of adjacent transitional grassland (this macroplot was less homogeneous than others). Forbs are prominent throughout but subordinate to the other life forms in abundance. *Symphoricarpos albus* var. *laevigatus* dominates the shrubland portion of the site with a significant mixture of many of the same graminoids and forbs as in the grassland portion. Major graminoid species are, in order of abundance, *Poa pratensis* (non-native), *Elymus glaucus*, *Bromus carinatus*, and *Carex tumulicola*. The non-native *Plantago lanceolata* is the dominant forb at 15% cover. *Sanicula crassicaulis* and *Sanicula bipinnatifida* are also quite abundant, and *Lupinus densiflorus* var. *densiflorus* is notable in its presence in the grassy section. The forb *Erigeron speciosus* was noted in the community supporting *Castilleja levisecta* but not in the plot. This is of note because it is considered very rare in San Juan County (Atkinson and Sharpe 1993) and is also present in some *C. levisecta* sites on Whidbey Island. Moss cover is substantial. Subpopulation #1 is a relatively mesic (in comparison to Ebey's Bluff and Fort Casey) coastal bluff that does not correspond with described plant associations. Shrubs have probably increased over time on the most mesic portions in the absence of fire on adjacent former coastal prairies.

The Subpopulation #2 is a tiny remnant of relatively weedy herbaceous vegetation that was formerly more dominated by deciduous shrubs prior to mowing. It would have historically been part of a gently sloping coastal prairie, portions of which converted to shrubland and woodland with fire suppression. The vegetation is dominated by a mix of graminoids and forbs. *Hypochaeris radicata*, *Poa pratensis* and *Festuca rubra* are co-dominant (the first two are non-native, the third may be exotic at this location). Other prominent species are *Clinopodium douglasii*, *Rosa nutkana*, *Bromus carinatus*, *Holcus lanatus*, *Carex tumulicola*, *Castilleja levisecta*, and *Daucus carota*. Mosses and lichens are absent. This vegetation does not fit any plant association. It is dominated primarily by non-native species and has been highly altered by successional processes in the absence of fire and the presence of subsequent mowing.

3.3.3. San Juan Valley

General: The San Juan Valley site is an open, flat to sloping pasture and a nearby wet swale. According to the 1875 General Land Office maps (http://landprx.pdxproxy.blm.gov/lr/WA/t350n030w_001.jpg), the area that is now the San Juan Valley site was mapped as prairie, or at least as open land, although there is little evidence of prairie in the area, other than *Castilleja levisecta* and a nearby stand of oak. Most of the site is flat to gently SW-facing, and slopes are up to 15%. This site is approximately 1.7 km from the nearest salt water. There is *Castilleja levisecta* scattered over approximately 1 hectare in an area used as horse pasture and as a young pecan orchard. *C. levisecta* also occurs sporadically on both sides of a ditch that drain a wet swale. This very

large population had more than 7,000 individuals in 2003. The site is privately owned, and the owner is not allowing access at this time.

Geology and Soils: Surficial geology maps show the site as Vashon till (Youngmann 1978). The mapped soil type is Coveland gravelly silt loam (Schlots et al 1958). Coveland is derived from fine textured glacial till. Based on the soils analysis, the soils at the San Juan Valley site were sandy loams, although previous soil pits found stony loams, and the landowner indicated that the ground was extremely stony. The site had relatively high organic matter and nitrogen, which is not surprising since it is actively used as a pasture. The southern portion of the site is a jurisdictional wetland (i.e., it supports wetland soils and vegetation), and there are some *Castilleja levisecta* individuals in this portion of the site. This is the only known extant wetland area that supports *C. levisecta*.

Vegetation: Plant community data were not collected at the San Juan Valley site. This site is privately owned and access was denied in 2004. Native forbs noted at the site include *Fritillaria lanceolata*, *Pteridium aquilinum*, *Juncus effusus*, *Fragaria* sp., *Viola adunca*, *Solidago* sp., *Fragaria* sp., *Triphysaria pusillis*, *Sisyrinchium idahoense*, *Luzula* sp., *Dodecatheon hendersonii*, and *Achillea millefolium*. Non-native forbs and grasses include *Ranunculus* sp. (probably non-native), *Festuca (rubra?)*, *Anthoxanthum odoratum*, *Dactylis glomerata*, *Holcus lanatus.*, *Plantago lanceolata*, *Poa pratensis*, *Vicia hirsuta*, and *Senecio jacobaea*.

3.3.4. Alpha Islet

General: Alpha Islet is a very small (less than 1 hectare) low-lying island with an undulating, bouldery surface. The islet supports a population of more than 800 individuals of *Castilleja levisecta*. There has been no sign of decline in this population. The aspect is variable and includes northerly-facing slopes, and the slope is mostly gentle where the *Castilleja levisecta* occurs, 4 and 9% on the two plots.

Geology and Soils: Information on the mapped geological unit, soil type, and soil analysis is not available. However, surface soils were estimated by observation to be gravelly loam in one plot. Soils are shallow, and there are many scattered large rocks. Salt spray would be significant at this site.

Vegetation: The vegetation on Alpha Islet is dominated by forbs and varies substantially on a small scale. The two macroplots represent the vegetation well where they were placed but do not represent all the variations of composition present on the island. No single species dominated the first plot. The three most abundant species are the fern *Pteridium aquilinum* var. *pubescens*, the forb *Camassia leichtlinii* ssp. *suksdorfii*, and the grass *Festuca rubra*. *Castilleja levisecta* is prominent on this plot and moss (*Dicranum scoparium*) cover is 60

percent. The second plot is dominated by *Sanicula crassicaulis*, with *Camassia leichtlinii* ssp. *suksdorfii* and the bunchgrass *Deschampsia caespitosa* prominent. Moss is present with low cover on this plot. One other variation of vegetation that supported *Castilleja levisecta* that was noted briefly on the island but not sampled had some similarity to vegetation observed on three separate small San Juan islands in Washington. This cover type has relatively high percent cover of both *Camassia leichtlinii* and *Plectritis congesta*.

3.3.5. Trial Island

General: Trial Island (23 hectares) is a larger island than Alpha Islet, with more topographic relief. There is a large *Castilleja levisecta* population on the central and especially northern portion of Trial Island (approximately 3 hectares in size), with more than 2,000 individuals counted in 1994 and 2002. There has been no sign of decline in this population. The aspect on plots sampled ranges from 156 to 336° (SSE, WNW, and NNW) and the slope varies from 2-9%.

Geology and Soils: Information on the mapped geological unit and soil type is not available. Bedrock on Trial Island is gneissic with a discontinuous covering of fine glaciomarine sediments (M. Fairbarns, *in litt.* 2004). The site has shallow, sandy loam soil over bedrock. Soil analyses showed relatively high levels of organic matter. Salt spray could be significant at this site.

Vegetation: The deep-soil north-facing plot in the center of the island was co-dominated by *Camassia quamash* and *Plantago lanceolata*. Other species with substantial amounts of cover on this plot are the shrubs *Symphoricarpos albus* var. *laevigatus* and *Mahonia aquifolium*, grasses *Anthoxanthum odoratum*, *Festuca rubra*, and *Poa pratensis* and the forbs *Castilleja levisecta* and *Lomatium nudicaule*. The two clearly shallow-soil plots (one with exposed bedrock on the plot itself) were relatively similar to each other. They are co-dominated by *Camassia leichtlinii* ssp. *suksdorfii* and *Lomatium nudicaule*. Moss cover is substantial and once again dominated by *Dicranum scoparium*. *Festuca rubra* is prominent on one of the shallow-soil plots, but not the other.

3.3.6. Discussion of Northern Island sites

Trial Island and Alpha Islet have similarities vegetatively and environmentally, and are relatively distinct from the other sites. The vegetation on these islands has a low cover of non-native species, a high cover of native forbs, and does not correspond with described plant associations. This may be a result of both the rarity of relatively undisturbed herbaceous communities in the region and a relative lack of sampling of small islands. A number of native species have relatively high constancy in the 5 plots on Trial Island and Alpha Islet: *Rosa nutkana*, *Rubus ursinus*, *Mahonia aquifolium*, *Luzula comosa*, *Achillea millefolium* var. *occidentalis*, *Camassia leichtlinii* ssp. *suksdorfii*, *Cerastium*

arvense ssp. *strictum*, *Fritillaria affinis* var. *affinis*, *Lomatium nudicaule*, and *Sanicula crassicaulis*. Low lichen cover (<5%) is present on all of these plots, unlike most other sites, and moss, especially *Dicranum scoparium*, is often abundant.

Long Island is similar environmentally to Trial Island and Alpha Islet but differs vegetatively in being more grass-dominated.

On San Juan Island, historical records and soil surveys indicate that much of the southern portion of the island was once open prairie or grassland. We speculate that *Castilleja levisecta* was once more widespread in this area, and more connected geographically by prairie or grassland vegetation. Portions of this very large historic prairie area have shallow soils over bedrock and others have deep glacial deposits, so it is not surprising that we now find the few remaining populations on what appears to be a variety of soils and parent materials. It is interesting to note that none of the San Juan Island populations occur on very dry sites with shallow or gravelly soils.

4. GENERAL DISCUSSION AND RECOMMENDATIONS

4.1. Vegetation

Some of the interesting aspects of the vegetation associated with *Castilleja levisecta* in comparison to similar habitats are discussed below.

When moss is prominent, the dominant species is usually if not exclusively *Dicranum scoparium*. The abundant *Racomitrium canescens*, which occurs in many remaining prairies and grassy balds, was not recorded in any *Castilleja levisecta* plots. *Dicranum scoparium* is indicative of more moist conditions than *Racomitrium canescens*.

Festuca roemerii was found only at the south Puget Sound site and was not even present in small amounts at any other site. If it had been eliminated by grazing, we would expect to find at least a few remnant individuals, as we did at a highly degraded site in southwest Washington (Boistfort Prairie). We do not recommend planting *Festuca roemerii* on the northern Puget sites.

Carex tumulicola was surprisingly abundant on Whidbey and San Juan islands, and may have been significant in coastal prairie sites prior to European settlement, since there are few other native graminoids with potential to have significant cover.

Forbs dominate the vegetation at the two least disturbed northern sites (Trial Island and Alpha Islet) and at some of the others also. We speculate that the pre-settlement vegetation on the mesic coastal prairies of Whidbey and San Juan that now support *Castilleja levisecta* may have been historically dominated primarily by forbs, with graminoids such as *Carex tumulicola* as a significant secondary component. *Erigeron speciosus* was found at Rocky Prairie, several Whidbey Island *C. levisecta* populations and one population on San Juan Island. *E. speciosus* has only been collected once in the San Juans (Atkinson and Sharpe 1993).

Research is needed to determine whether the *Festuca rubra* at West Beach, Forbes Point, Bocker, False Bay, and probably San Juan Valley is native or not. Genetic work may be needed to make this determination. Until such work is completed we would not recommend planting this species anywhere except on coastal bluff habitats or salt spray areas on small islands.

We also recommend that a full plant species list is collected for each site, since plots do not necessarily capture the full plant diversity of each site.

4.2. Soils and physical characteristics

There is a wide range of soils and physical characteristics, from a wet swale to a steep, sandy bluff. However, there are some commonalities, particularly within the three geographic areas. Nearly all of the soils are well drained. *Castilleja levisecta* can tolerate shallow, rocky soils or very sandy soils. The aspect on Whidbey Island and in the San Juans is generally south, southwest, or west, and these aspects are also the aspects that more generally supported grasslands or prairies. Whidbey Island also has a number of flat or nearly flat sites. The British Columbia islands, which are exposed to high winds and salt spray, support *C. levisecta* on more northerly aspects.

From the soils analysis, in general, organic matter is very high, phosphorus is low to very low, magnesium is high to very high, calcium is low to very low, pH is acidic, iron is very high, copper is very low, soluble salts are low, percent sand is high, percent clay is low. Most sites lack significant gravel in the upper soil layers, though some are rocky.

For reintroduction sites, we would recommend matching substrate and aspect to the geographically closest known population. Even small changes of aspect on steep slopes may create conditions that are not favorable for *Castilleja levisecta*.

5. DATA TABLES

5.1. *Physical characteristics*

PHYSICAL CHARACTERISTICS OF GOLDEN PAINTBRUSH SITES

Site	Aspect	Slope	Mapped soil type	Surficial geology	Distance from salt water/bluff height*
South Puget Sound					
Rocky Prairie	All	0-25%	Spanaway-Nisqually	Vashon outwash	15 km
Whidbey Island					
Fort Casey	232° to 285°	9-90%	Hoypus loamy sand	Vashon drift	35 m / low
Ebey's Bluff	187°	90%	Rough broken land	Pleistocene sand	25 m / high
Bocker	N/A	flat	Hoypus coarse loamy sand	Vashon drift	100 m / high
Forbes Point	237°	2%	Casey loam	Everson glaciomarine drift	25 m / low
West Beach	258°	7%	Bozarth fine sandy loam	Vashon till?	80 m / moderate
Northern Islands					
Long Island	N/A	N/A	San Juan gravelly sandy loam	Flysch-type rocks	< 10 m / low
False Bay	160-275°	4-74%	Coveland gravelly silt loam?, Bow silt loam?	Orcas formation	5 m - 250 m / Imoderate
San Juan Valley	180-225° ?	0-15%	Coveland gravelly silt loam	Vashon till	1.7 km
Alpha Islet	317-357°	2-9%	Unknown (shallow gravelly loam)	Unknown (bedrock)	10-15 m / low
Trial Island	156 -336°	2-9%	Unknown (shallow gravelly loam)	Unknown (bedrock)	10 m / low

* approximate distance from edge of population closest to saltwater to mean high tide line.

5.2. *Vegetation composition*

Tables 1 through 11 summarize the vegetation data collected at each site. Table 12-14 combine the same data into habitat types. In each table, “**Cover**” refers to mean relative cover, the mean percent crown cover on the plots where the species occurs. “+” means "trace" or less than 0.5 percent cover. “**Mean absolute cover**” includes all plots, even those where the species does not occur. **Constancy** is the percent of plots within which the species occurs

Site Characteristics of Golden Paintbrush Populations

VEGETATION TABLE 1: All plots at all sites (20 plots)						
Kartesz 2003 Name	Common Name	Constancy	Mean Relative Cover	Mean Absolute Cover	Minimum	Maximum
Trees		5	4.0	0.2	0	4
Pseudotsuga menziesii var menziesii	Douglas-fir	5	4.0	0.2	0	4
Shrubs, Subshrubs, Woody Vines		75	10.4	7.8	0	40
Amelanchier alnifolia	serviceberry	5	0.3	0.0	0	0.3
Mahonia aquifolium	tall Oregongrape	35	3.2	1.1	0	7
Rosa nutkana	nootka rose	60	3.0	1.8	0	9
Rubus ursinus ssp macropetalus	trailing blackberry	55	3.3	1.8	0	15
Symphoricarpos albus var laevigatus	common snowberry	25	13.4	3.4	0	40
Graminoids		95	48.5	46.1	0	85
Agrostis spp	bentgrass	30	4.6	1.4	0	8
Aira caryophylla	silver hairgrass	40	0.4	0.2	0	1
Aira praecox	early hairgrass	25	1.0	0.2	0	3
Anthoxanthum odoratum	sweet vernalgrass	40	8.3	3.3	0	20
Arrhenatherum elatius	tall oatgrass	5	2.0	0.1	0	2
Bromus carinatus	California brome	50	4.8	2.4	0	15
Bromus hordeaceus	soft brome	35	2.1	0.7	0	8
Bromus rigidus	rip-gut brome	20	8.2	1.6	0	30
Carex inops ssp inops	long-stolon sedge	20	14.5	2.9	0	20
Carex rossii	Ross's sedge	25	0.3	0.1	0	0.3
Carex tumulicola	foothill sedge	30	24.2	7.3	0	50
Cynosurus echinatus	hedgehog dogtail	5	0.3	0.0	0	0.3
Dactylis glomerata	orchard grass	55	3.5	1.9	0	20
Danthonia californica	California danthonia	20	0.7	0.1	0	1
Deschampsia caespitosa	tufted hairgrass	10	4.0	0.4	0	6
Elymus glaucus	blue wildrye	15	6.3	1.0	0	15
Schedonorus phoenix	tall fescue	10	0.7	0.1	0	1
Vulpia bromoides	barren fescue	30	4.4	1.3	0	15
Festuca roemerii	Roemer's fescue	20	32.5	6.5	0	40
Festuca rubra	red fescue	55	15.0	8.3	0	35
Holcus lanatus	common velvet grass	45	5.9	2.6	0	25
Koeleria macrantha	prairie junegrass	20	0.5	0.1	0	1
Leymus mollis ssp mollis	dune wildrye	15	0.5	0.1	0	1
Lolium perenne	perennial ryegrass	5	1.0	0.1	0	1
Luzula comosa	Pacific wood-rush	70	0.6	0.4	0	2
Luzula multiflora ssp multiflora var multiflora	many-flowered wood-rush	20	0.5	0.1	0	1
Poa bulbosa	bulbous bluegrass	5	0.3	0.0	0	0.3
Poa confinis	coastline bluegrass	5	0.3	0.0	0	0.3
Poa pratensis	Kentucky bluegrass	90	9.5	8.6	0	55

Site Characteristics of Golden Paintbrush Populations

VEGETATION TABLE 1: All plots at all sites (20 plots)						
Kartesz 2003 Name	Common Name	Constancy	Mean Relative Cover	Mean Absolute Cover	Minimum	Maximum
Forbs and Ferns		95	46.6	44.3	0	70
Achillea millefolium var occidentalis	yarrow	95	1.1	1.0	0	4
Aphanes arvensis	western lady's-mantle	5	0.3	0.0	0	0.3
Allium acuminatum	Hooker's onion	10	0.7	0.1	0	1
Antennaria rosea	rosy pussytoes	10	0.3	0.0	0	0.3
Anthriscus caucalis	bur chervil	5	0.3	0.0	0	0.3
Aquilegia formosa	red columbine	10	1.2	0.1	0	2
Artemisia campestris ssp borealis var scouleriana	northern wormwood	5	1.0	0.1	0	1
Sericocarpus rigidus	white-top aster	5	0.3	0.0	0	0.3
Triteleia hyacinthina	hyacinth brodiaea	15	2.1	0.3	0	4
Camassia leichtlinii ssp suksdorfii	great camas	25	15.1	3.8	0	30
Camassia quamash	common camas	25	5.8	1.5	0	20
Castilleja levisecta	golden paintbrush	100	2.5	2.5	0.3	6
Castilleja miniata	scarlet paintbrush	10	0.3	0.0	0	0.3
Cerastium arvense ssp strictum	field chickweed	50	0.8	0.4	0	3
Cerastium glomeratum	sticky chickweed	10	0.3	0.0	0	0.3
Leucanthemum vulgare	oxeye daisy	15	12.0	1.8	0	20
Cirsium arvense	Canada thistle	10	0.7	0.1	0	1
Cirsium brevistylum	short-styled thistle	15	0.3	0.0	0	0.3
Cirsium vulgare	bull thistle	25	0.6	0.1	0	1
Crepis capillaris	smooth hawkbeard	10	0.7	0.1	0	1
Daucus carota	Queen Anne's lace	30	2.3	0.7	0	5
Dodecatheon hendersonii ssp hendersonii	Henderson's shooting star	10	0.3	0.0	0	0.3
Dodecatheon pulchellum	handsome shooting star	5	0.3	0.0	0	0.3
Eriophyllum lanatum var lanatum	woolly sunflower	30	3.4	1.0	0	8
Erigeron speciosus var speciosus	showy fleabane	25	0.6	0.2	0	2
Fragaria vesca ssp bracteata	woods strawberry	10	2.5	0.3	0	3
Fragaria virginiana ssp platypetala	common strawberry	40	4.0	1.6	0	15
Fritillaria affinis var affinis	chocolate lily	40	1.1	0.4	0	3
Galium aparine	cleavers	15	0.3	0.0	0	0.3
Geranium carolinianum var carolinianum	Carolina geranium	5	0.3	0.0	0	0.3
Geranium dissectum	cut-leaf geranium	5	0.3	0.0	0	0.3
Grindelia stricta var stricta	Oregon gumweed	20	0.5	0.1	0	1
Heracleum maximum	cow-parsnip	20	5.3	1.1	0	15
Hieracium cynoglossoides	houndstongue hawkweed	20	4.0	0.8	0	6
Hypericum perforatum	common St. John's-wort	20	1.4	0.3	0	4
Hypochaeris radicata	hairy cat's-ear	80	3.8	3.0	0	35
Lathyrus nevadensis ssp lanceolatus var pilosellus	Nuttall's peavine	5	4.0	0.2	0	4
Lomatium dissectum var dissectum	fern-leaved lomatium	5	1.0	0.1	0	1
Lomatium nudicaule	bare-stem lomatium	35	8.8	3.1	0	20

Site Characteristics of Golden Paintbrush Populations

VEGETATION TABLE 1: All plots at all sites (20 plots)

Kartesz 2003 Name	Common Name	Constancy	Mean Relative Cover	Mean Absolute Cover	Minimum	Maximum
Lomatium triternatum var triternatum	nine-leaf lomatium	10	1.5	0.2	0	2
Lomatium utriculatum	spring-gold	20	1.5	0.3	0	5
Lotus denticulatus	meadow deervetch	5	1.0	0.1	0	1
Lotus micranthus	small-flowered deervetch	15	0.9	0.1	0	2
Lupinus albicaulis var albicaulis	sickle-keeled lupine	15	7.3	1.1	0	10
Lupinus bicolor ssp bicolor	two-colored lupine	5	0.3	0.0	0	0.3
Lupinus densiflorus var densiflorus	dense-flowered lupine	15	8.0	1.2	0	20
Lupinus lepidus	prairie lupine	5	0.3	0.0	0	0.3
Lupinus littoralis	seashore lupine	5	4.0	0.2	0	4
Microseris laciniata ssp laciniata	cut-leaf microseris	20	0.5	0.1	0	1
Myosotis discolor	yellow-and-blue forget-me-not	30	0.3	0.1	0	0.3
Orobanche uniflora	naked broomrape	5	0.3	0.0	0	0.3
Parentucellia viscosa	yellow parentucellia	5	0.3	0.0	0	0.3
Plantago lanceolata	English plantain	75	9.5	7.1	0	30
Polystichum munitum	sword fern	5	2.0	0.1	0	2
Potentilla gracilis var gracilis	graceful cinquefoil	15	1.4	0.2	0	2
Prunella vulgaris ssp lanceolata	self-heal	25	1.3	0.3	0	2
Pteridium aquilinum var pubescens	bracken fern	50	5.9	3.0	0	20
Ranunculus californicus	California buttercup	10	0.7	0.1	0	1
Ranunculus occidentalis var occidentalis	western buttercup	35	1.9	0.7	0	5
Rumex acetosella	sheep sorrel	65	0.8	0.6	0	6
Sanicula arctopoides	bear's foot sanicle	5	0.3	0.0	0	0.3
Sanicula bipinnatifida	purple sanicle	10	1.7	0.2	0	3
Sanicula crassicaulis var crassicaulis	Pacific sanicle	70	9.6	6.7	0	35
Clinopodium douglasii	yerba buena	10	6.0	0.6	0	10
Senecio jacobea	tansy ragwort	5	0.3	0.0	0	0.3
Sherardia arvensis	blue field-madder	5	0.3	0.0	0	0.3
Silene menziesii ssp menziesii	white catchfly	5	0.3	0.0	0	0.3
Silene scouleri ssp grandis	Scouler's catchfly	10	1.2	0.1	0	2
Sisyrinchium idahoense	Idaho blue-eyed grass	20	0.5	0.1	0	1
Solidago canadensis var salebrosa	Canadian goldenrod	40	3.5	1.4	0	20
Solidago missouriensis var tolmieana	Missouri goldenrod	20	1.8	0.4	0	3
Solidago simplex ssp simplex var simplex	dwarf goldenrod	15	0.5	0.1	0	1
Sonchus spp	sow-thistle	5	0.3	0.0	0	0.3
Taraxacum officinale	common dandelion	45	1.0	0.5	0	3
Teesdalia nudicaulis	common shepherd's-cress	20	0.8	0.2	0	1
Tragopogon dubius	yellow salsify	5	0.3	0.0	0	0.3
Trifolium dubium	suckling clover	55	1.8	1.0	0	10
Trifolium pratense	red clover	15	0.3	0.0	0	0.3

Site Characteristics of Golden Paintbrush Populations

VEGETATION TABLE 1: All plots at all sites (20 plots)						
Kartesz 2003 Name	Common Name	Constancy	Mean Relative Cover	Mean Absolute Cover	Minimum	Maximum
Trifolium repens	white clover	20	1.0	0.2	0	3
Trifolium willdenowii	tomcat clover	5	0.3	0.0	0	0.3
Veronica officinalis	Paul's betony	5	1.0	0.1	0	1
Vicia americana ssp americana	American vetch	20	2.1	0.4	0	3
Vicia villosa	woolly vetch	10	6.0	0.6	0	10
Vicia hirsuta	hairy vetch	75	1.5	1.1	0	5
Vicia sativa	common vetch	75	1.5	1.2	0	10
Viola adunca var adunca	early blue violet	5	1.0	0.1	0	1
Zigadenus venenosus var venenosus	meadow death camas	10	2.5	0.3	0	3
Lichens		45	2.1	0.9	0	9
Moss		65	31.2	20.3	0	70
Rock		5	0.3	0.0	0	0.3
Bare Soil		45	1.9	0.8	0	10

Site Characteristics of Golden Paintbrush Populations

VEGETATION TABLE 2: Rocky Prairie (4 plots)					
Kartesz 2003 Name	Common Name	Cover	Constancy	min	max
Graminoids		65	100	60	70
Agrostis spp	bentgrass	5	100	2	8
Aira caryophyllea	silver hairgrass	+	25	0	+
Aira praecox	early hairgrass	1	50	0	1
Anthoxanthum odoratum	sweet vernalgrass	12	75	0	20
Carex inops ssp inops	long-stolon sedge	15	100	8	20
Danthonia californica	California danthonia	1	50	0	1
Festuca roemerii	Roemer's fescue	33	100	15	40
Holcus lanatus	common velvet grass	+	25	0	+
Koeleria macrantha	prairie junegrass	1	50	0	1
Luzula comosa	Pacific wood-rush	+	25	0	+
Luzula multiflora ssp multiflora var multiflora	many-flowered wood-rush	+	100	+	1
Poa pratensis	Kentucky bluegrass	3	50	0	4
Forbs and Ferns		48	100	30	60
Achillea millefolium var occidentalis	yarrow	1	100	+	1
Aphanes arvensis	western lady's-mantle	+	25	0	+
Antennaria rosea	rosy pussytoes	+	50	0	+
Sericocarpus rigidus	white-top aster	+	25	0	+
Camassia quamash	common camas	2	100	1	3
Castilleja levisecta	golden paintbrush	3	100	1	4
Cerastium arvense ssp strictum	field chickweed	+	75	0	+
Leucanthemum vulgare	oxeye daisy	12	75	0	20
Crepis capillaris	smooth hawkbeard	1	50	0	1
Dodecatheon hendersonii ssp hendersonii	Henderson's shooting star	+	50	0	+
Eriophyllum lanatum var lanatum	woolly sunflower	5	100	+	8
Erigeron speciosus var speciosus	showy fleabane	+	50	0	+
Fragaria virginiana ssp platypetala	common strawberry	2	100	+	4
Fritillaria affinis var affinis	chocolate lily	+	25	0	+
Geranium carolinianum var carolinianum	Carolina geranium	+	25	0	+
Hieracium cynoglossoides	houndstongue hawkweed	4	100	2	6
Hypericum perforatum	common St. John's-wort	1	100	+	4
Hypochaeris radicata	hairy cat's-ear	2	75	0	3
Lomatium triternatum var triternatum	nine-leaf lomatium	2	50	0	2
Lotus micranthus	small-flowered deervetch	+	50	0	+
Lupinus albicaulis var albicaulis	sickle-keeled lupine	7	75	0	10
Lupinus lepidus	prairie lupine	+	25	0	+
Microseris laciniata ssp laciniata	cut-leaf microseris	+	100	+	1
Plantago lanceolata	English plantain	1	25	0	1
Potentilla gracilis var gracilis	graceful cinquefoil	1	75	0	2
Prunella vulgaris ssp lanceolata	self-heal	1	100	+	2
Pteridium aquilinum var pubescens	bracken fern	7	100	1	20
Ranunculus occidentalis var occidentalis	western buttercup	2	100	1	5
Rumex acetosella	sheep sorrel	+	75	0	+
Senecio jacobea	tansy ragwort	+	25	0	+
Sisyrinchium idahoense	Idaho blue-eyed grass	+	75	0	+

Site Characteristics of Golden Paintbrush Populations

VEGETATION TABLE 2: Rocky Prairie (4 plots)					
Kartesz 2003 Name	Common Name	Cover	Constancy	min	max
Solidago canadensis var salebrosa	Canadian goldenrod	1	75	0	2
Solidago missouriensis var tolmieana	Missouri goldenrod	2	100	1	3
Solidago simplex ssp simplex var simplex	dwarf goldenrod	1	75	0	1
Taraxacum officinale	common dandelion	2	50	0	2
Teesdalia nudicaulis	common shepherd's-cress	1	100	+	1
Tragopogon dubius	yellow salsify	+	25	0	+
Trifolium dubium	suckling clover	+	50	0	+
Trifolium repens	white clover	+	25	0	+
Veronica officinalis	Paul's betony	1	25	0	1
Viola adunca var adunca	early blue violet	1	25	0	1
Lichens		1	100	+	2
Moss		53	100	30	70
Rock					
Bare Soil		1	100	+	1

Site Characteristics of Golden Paintbrush Populations

VEGETATION TABLE 3: Ft. Casey (3 plots)

Kartesz 2003 Name	Common Name	Cover	Constancy	min	max
Shrubs, Subshrubs, Woody Vines					
		18	67	0	35
Rosa nutkana	nootka rose	2	67	0	3
Rubus ursinus ssp macropetalus	trailing blackberry	15	33	0	15
Symphoricarpos albus var laevigatus	common snowberry	15	33	0	15
Graminoids					
		38	100	30	50
Aira caryophyllea	silver hairgrass	+	67	0	+
Aira praecox	early hairgrass	+	33	0	+
Bromus carinatus	California brome	1	100	+	1
Bromus hordeaceus	soft brome	3	100	+	8
Bromus rigidus	rip-gut brome	1	67	0	2
Dactylis glomerata	orchard grass	6	67	0	7
Vulpia bromoides	barren fescue	6	100	+	15
Festuca rubra	red fescue	35	33	0	35
Holcus lanatus	common velvet grass	13	67	0	25
Leymus mollis ssp mollis	dune wildrye	+	67	0	+
Luzula comosa	Pacific wood-rush	+	33	0	+
Poa pratensis	Kentucky bluegrass	6	100	+	15
Forbs and Ferns					
		33	100	20	60
Achillea millefolium var occidentalis	yarrow	2	100	+	4
Castilleja levisecta	golden paintbrush	1	100	+	1
Cerastium glomeratum	sticky chickweed	+	33	0	+
Cirsium brevistylum	short-styled thistle	+	33	0	+
Cirsium vulgare	bull thistle	1	33	0	1
Galium aparine	cleavers	+	33	0	+
Grindelia stricta var stricta	Oregon gumweed	1	33	0	1
Heracleum maximum	cow-parsnip	3	67	0	4
Hypochaeris radicata	hairy cat's-ear	1	100	+	2
Lomatium nudicaule	bare-stem lomatium	15	33	0	15
Lotus denticulatus	meadow deervetch	1	33	0	1
Lupinus densiflorus var densiflorus	dense-flowered lupine	11	67	0	20
Myosotis discolor	yellow-and-blue forget-me-not	+	67	0	+
Plantago lanceolata	English plantain	13	100	+	30
Polystichum munitum	sword fern	2	33	0	2
Rumex acetosella	sheep sorrel	+	33	0	+
Sanicula crassicaulis var crassicaulis	Pacific sanicle	6	100	4	10
Clinopodium douglasii	yerba buena	2	33	0	2
Solidago canadensis var salebrosa	Canadian goldenrod	1	33	0	1
Sonchus spp	sow-thistle	+	33	0	+
Taraxacum officinale	common dandelion	+	33	0	+
Trifolium dubium	suckling clover	4	100	+	10
Trifolium pratense	red clover	+	67	0	+
Trifolium repens	white clover	3	33	0	3
Vicia americana ssp americana	American vetch	+	33	0	+

Site Characteristics of Golden Paintbrush Populations

VEGETATION TABLE 3: Ft. Casey (3 plots)

Kartesz 2003 Name	Common Name	Cover	Constancy	min	max
Vicia hirsuta	hairy vetch	+	100	+	+
Vicia sativa	common vetch	1	100	+	1
Bare Soil		10	33	0	10

Site Characteristics of Golden Paintbrush Populations

VEGETATION TABLE 4: Ebey's Bluff (1 plot)		
Kartesz 2003 Name	Common Name	Cover
Shrubs, Subshrubs, Woody Vines		
Mahonia aquifolium	tall Oregongrape	5
Graminoids		
Aira caryophyllea	silver hairgrass	+
Bromus hordeaceus	soft brome	+
Bromus rigidus	rip-gut brome	30
Dactylis glomerata	orchard grass	1
Festuca rubra	red fescue	30
Koeleria macrantha	prairie junegrass	+
Luzula comosa	Pacific wood-rush	1
Poa pratensis	Kentucky bluegrass	2
Forbs and Ferns		
Achillea millefolium var occidentalis	yarrow	1
Artemisia campestris ssp borealis var scouleriana	northern wormwood	1
Castilleja levisecta	golden paintbrush	3
Castilleja miniata	scarlet paintbrush	+
Cerastium arvense ssp strictum	field chickweed	3
Daucus carota	Queen Anne's lace	+
Eriophyllum lanatum var lanatum	woolly sunflower	1
Erigeron speciosus var speciosus	showy fleabane	2
Grindelia stricta var stricta	Oregon gumweed	+
Hypochaeris radicata	hairy cat's-ear	1
Lomatium utriculatum	spring-gold	+
Lupinus littoralis	seashore lupine	4
Plantago lanceolata	English plantain	8
Pteridium aquilinum var pubescens	bracken fern	1
Rumex acetosella	sheep sorrel	6
Silene menziesii ssp menziesii	white catchfly	+
Solidago canadensis var salebrosa	Canadian goldenrod	2
Vicia hirsuta	hairy vetch	+
Vicia sativa	common vetch	+
Moss		
Bare Soil		
		1
		2

Site Characteristics of Golden Paintbrush Populations

VEGETATION TABLE 5: Bocker (2 plots)

Kartesz 2003 Name	Common Name	Cover	Constancy	min	max
Shrubs, Subshrubs, Woody Vines					
		11	100	6	15
Rosa nutkana	nootka rose	8	100	6	9
Rubus ursinus ssp macropetalus	trailing blackberry	6	50	0	6
Graminoids					
		63	100	55	70
Agrostis spp	bentgrass	8	50	0	8
Anthoxanthum odoratum	sweet vernalgrass	8	100	6	10
Bromus carinatus	California brome	+	50	0	+
Carex tumulicola	foothill sedge	35	100	20	50
Dactylis glomerata	orchard grass	11	100	1	20
Festuca rubra	red fescue	4	50	0	4
Holcus lanatus	common velvet grass	10	50	0	10
Luzula comosa	Pacific wood-rush	+	100	+	+
Poa pratensis	Kentucky bluegrass	9	100	3	15
Forbs and Ferns					
		65	100	60	70
Achillea millefolium var occidentalis	yarrow	3	100	2	3
Castilleja levisecta	golden paintbrush	1	100	+	2
Castilleja miniata	scarlet paintbrush	+	50	0	+
Daucus carota	Queen Anne's lace	+	100	+	+
Erigeron speciosus var speciosus	showy fleabane	+	50	0	+
Fragaria vesca ssp bracteata	woods strawberry	3	50	0	3
Heracleum maximum	cow-parsnip	8	100	+	15
Hypochaeris radicata	hairy cat's-ear	1	100	+	1
Myosotis discolor	yellow-and-blue forget-me-not	+	100	+	+
Plantago lanceolata	English plantain	9	100	8	10
Ranunculus occidentalis var occidentalis	western buttercup	1	50	0	1
Rumex acetosella	sheep sorrel	+	50	0	+
Sanicula crassicaulis var crassicaulis	Pacific sanicle	23	100	10	35
Solidago canadensis var salebrosa	Canadian goldenrod	11	100	2	20
Taraxacum officinale	common dandelion	2	100	1	3
Trifolium dubium	suckling clover	1	100	+	1
Vicia americana ssp americana	American vetch	3	50	0	3
Vicia hirsuta	hairy vetch	3	100	1	5
Vicia sativa	common vetch	6	100	1	10

Site Characteristics of Golden Paintbrush Populations

VEGETATION TABLE 6: Forbes Point (2 plots)

Kartesz 2003 Name	Common Name	Cover	Constancy	min	max
Shrubs, Subshrubs, Woody Vines		3	100	2	3
Mahonia aquifolium	tall Oregon grape	1	100	+	1
Rosa nutkana	nootka rose	+	50	0	+
Rubus ursinus ssp macropetalus	trailing blackberry	2	100	1	2
Symphoricarpos albus var laevigatus	common snowberry				
Graminoids		80	100	75	85
Aira caryophyllaea	silver hairgrass	+	100	+	+
Bromus carinatus	California brome	12	100	8	15
Bromus hordeaceus	soft brome	1	50	0	1
Carex tumulicola	foothill sedge	25	50	0	25
Dactylis glomerata	orchard grass	1	50	0	1
Schedonorus phoenix	tall fescue	1	50	0	1
Vulpia bromoides	barren fescue	+	50	0	+
Festuca rubra	red fescue	15	100	10	20
Holcus lanatus	common velvet grass	3	100	1	5
Luzula comosa	Pacific wood-rush	1	100	+	1
Poa pratensis	Kentucky bluegrass	38	100	20	55
Forbs and Ferns		43	100	30	55
Achillea millefolium var occidentalis	yarrow	2	100	+	3
Anthriscus caucalis	bur chervil	+	50	0	+
Castilleja levisecta	golden paintbrush	3	100	2	4
Cerastium glomeratum	sticky chickweed	+	50	0	+
Cirsium arvense	Canada thistle	1	50	0	1
Cirsium brevistylum	short-styled thistle	+	50	0	+
Cirsium vulgare	bull thistle	1	100	+	1
Daucus carota	Queen Anne's lace	4	100	4	4
Galium aparine	cleavers	+	50	0	+
Geranium dissectum	cut-leaf geranium	+	50	0	+
Hypochaeris radicata	hairy cat's-ear	+	50	0	+
Plantago lanceolata	English plantain	13	100	10	15
Pteridium aquilinum var pubescens	bracken fern	+	50	0	+
Rumex acetosella	sheep sorrel	1	50	0	1
Sanicula crassicaulis var crassicaulis	Pacific sanicle	11	100	6	15
Taraxacum officinale	common dandelion	1	100	+	1
Trifolium dubium	suckling clover	3	100	2	3
Trifolium repens	white clover	+	100	+	+
Vicia villosa	woolly vetch	6	100	2	10
Vicia hirsuta	hairy vetch	3	100	2	3
Vicia sativa	common vetch	2	100	1	2
Moss		33	100	30	35

Site Characteristics of Golden Paintbrush Populations

VEGETATION TABLE 7: West Beach (1 plot)		
Kartesz 2003 Name	Common Name	cover
Shrubs, Subshrubs, Woody Vines		4
Rosa nutkana	nootka rose	2
Rubus ursinus ssp macropetalus	trailing blackberry	2
Graminoids		65
Anthoxanthum odoratum	sweet vernalgrass	8
Bromus carinatus	California brome	+
Carex rossii	Ross's sedge	+
Carex tumulicola	foothill sedge	35
Dactylis glomerata	orchard grass	+
Festuca rubra	red fescue	20
Holcus lanatus	common velvet grass	4
Leymus mollis ssp mollis	dune wildrye	1
Poa pratensis	Kentucky bluegrass	3
Forbs and Ferns		35
Achillea millefolium var occidentalis	yarrow	+
Castilleja levisecta	golden paintbrush	2
Erigeron speciosus var speciosus	showy fleabane	+
Fragaria virginiana ssp platypetala	common strawberry	15
Fritillaria affinis var affinis	chocolate lily	1
Lomatium nudicaule	bare-stem lomatium	+
Myosotis discolor	yellow-and-blue forget-me-not	+
Plantago lanceolata	English plantain	10
Pteridium aquilinum var pubescens	bracken fern	5
Rumex acetosella	sheep sorrel	+
Sanicula crassicaulis var crassicaulis	Pacific sanicle	1
Solidago canadensis var salebrosa	Canadian goldenrod	+
Taraxacum officinale	common dandelion	+
Vicia hirsuta	hairy vetch	5
Vicia sativa	common vetch	+

Site Characteristics of Golden Paintbrush Populations

VEGETATION TABLE 8: False Bay - Subpop. #1 (1 plot)		
Kartesz 2003 Name	Common Name	Cover
Trees		
Pseudotsuga menziesii var menziesii	Douglas-fir	4
Shrubs, Subshrubs, Woody Vines		
Amelanchier alnifolia	serviceberry	+
Rubus ursinus ssp macropetalus	trailing blackberry	5
Symphoricarpos albus var laevigatus	common snowberry	40
Graminoids		
		55
Aira caryophylla	silver hairgrass	+
Bromus carinatus	California brome	15
Bromus hordeaceus	soft brome	4
Bromus rigidus	rip-gut brome	+
Carex tumulicola	foothill sedge	10
Dactylis glomerata	orchard grass	2
Elymus glaucus	blue wildrye	15
Vulpia bromoides	barren fescue	1
Festuca rubra	red fescue	1
Koeleria macrantha	prairie junegrass	+
Lolium perenne	perennial ryegrass	1
Luzula comosa	Pacific wood-rush	+
Poa pratensis	Kentucky bluegrass	20
Forbs and Ferns		
		35
Achillea millefolium var occidentalis	yarrow	+
Aquilegia formosa	red columbine	+
Castilleja levisecta	golden paintbrush	2
Cerastium arvense ssp strictum	field chickweed	1
Cirsium vulgare	bull thistle	+
Fragaria vesca ssp bracteata	woods strawberry	2
Fragaria virginiana ssp platypetala	common strawberry	+
Hypochaeris radicata	hairy cat's-ear	2
Lupinus densiflorus var densiflorus	dense-flowered lupine	2
Plantago lanceolata	English plantain	15
Ranunculus occidentalis var occidentalis	western buttercup	+
Sanicula bipinnatifida	purple sanicle	3
Sanicula crassicaulis var crassicaulis	Pacific sanicle	4
Taraxacum officinale	common dandelion	+
Trifolium dubium	suckling clover	2
Vicia americana ssp americana	American vetch	2
Vicia hirsuta	hairy vetch	1
Moss		
		35
Bare Soil		
		+

Site Characteristics of Golden Paintbrush Populations

VEGETATION TABLE 9: False Bay - Subpop. #2 (1 plot)		
Kartesz 2003 Name	Common Name	Cover
Shrubs, Subshrubs, Woody Vines		10
Rosa nutkana	nootka rose	8
Rubus ursinus ssp macropetalus	trailing blackberry	1
Symphoricarpos albus var laevigatus	common snowberry	1
Graminoids		55
Aira caryophyllea	silver hairgrass	1
Arrhenatherum elatius	tall oatgrass	2
Bromus carinatus	California brome	7
Carex rossii	Ross's sedge	+
Carex tumulicola	foothill sedge	5
Dactylis glomerata	orchard grass	1
Elymus glaucus	blue wildrye	1
Schedonorus phoenix	tall fescue	+
Festuca rubra	red fescue	20
Holcus lanatus	common velvet grass	7
Luzula comosa	Pacific wood-rush	2
Poa pratensis	Kentucky bluegrass	20
Forbs and Ferns		70
Achillea millefolium var occidentalis	yarrow	1
Aquilegia formosa	red columbine	2
Castilleja levisecta	golden paintbrush	5
Cirsium arvense	Canada thistle	+
Cirsium brevistylum	short-styled thistle	+
Cirsium vulgare	bull thistle	+
Daucus carota	Queen Anne's lace	5
Fritillaria affinis var affinis	chocolate lily	+
Hypochaeris radicata	hairy cat's-ear	35
Lathyrus nevadensis ssp lanceolatus var pilosellus	Nuttall's peavine	4
Myosotis discolor	yellow-and-blue forget-me-not	+
Parentucellia viscosa	yellow parentucellia	+
Plantago lanceolata	English plantain	4
Prunella vulgaris ssp lanceolata	self-heal	1
Pteridium aquilinum var pubescens	bracken fern	3
Ranunculus occidentalis var occidentalis	western buttercup	3
Sanicula crassicaulis var crassicaulis	Pacific sanicle	2
Clinopodium douglasii	yerba buena	10
Sisyrinchium idahoense	Idaho blue-eyed grass	1
Trifolium dubium	suckling clover	+
Trifolium pratense	red clover	+
Vicia hirsuta	hairy vetch	1
Vicia sativa	common vetch	1
Bare Soil		1

Site Characteristics of Golden Paintbrush Populations

VEGETATION TABLE 10: Alpha Islet (2 plots)					
Kartesz 2003 Name	Common Name	Cover	Constancy	min	max
Shrubs, Subshrubs, Woody Vines		5	100	2	8
Mahonia aquifolium	tall Oregongrape	5	50	0	5
Rosa nutkana	nootka rose	2	100	1	2
Rubus ursinus ssp macropetalus	trailing blackberry	2	100	1	2
Graminoids		11	100	6	15
Carex rossii	Ross's sedge	+	50	0	+
Cynosurus echinatus	hedgehog dogtail	+	50	0	+
Dactylis glomerata	orchard grass	+	50	0	+
Deschampsia caespitosa	tufted hairgrass	4	100	2	6
Festuca rubra	red fescue	15	50	0	15
Holcus lanatus	common velvet grass	+	50	0	+
Luzula comosa	Pacific wood-rush	1	100	+	1
Poa pratensis	Kentucky bluegrass	+	100	+	+
Forbs and Ferns		55	100	55	55
Achillea millefolium var occidentalis	yarrow	+	100	+	+
Allium acuminatum	Hooker's onion	+	50	0	+
Triteleia hyacinthina	hyacinth brodiaea	+	50	0	+
Camassia leichtlinii ssp suksdorfii	great camas	13	100	10	15
Castilleja levisecta	golden paintbrush	4	100	2	6
Cerastium arvense ssp strictum	field chickweed	1	100	1	1
Fragaria virginiana ssp platypetala	common strawberry	9	50	0	9
Fritillaria affinis var affinis	chocolate lily	2	100	+	3
Grindelia stricta var stricta	Oregon gumweed	+	50	0	+
Hypochaeris radicata	hairy cat's-ear	4	100	3	4
Lomatium dissectum var dissectum	fern-leaved lomatium	1	50	0	1
Lomatium nudicaule	bare-stem lomatium	1	100	+	1
Lotus micranthus	small-flowered deervetch	2	50	0	2
Lupinus bicolor ssp bicolor	two-colored lupine	+	50	0	+
Pteridium aquilinum var pubescens	bracken fern	20	50	0	20
Ranunculus californicus	California buttercup	1	100	+	1
Rumex acetosella	sheep sorrel	1	100	+	1
Sanicula bipinnatifida	purple sanicle	+	50	0	+
Sanicula crassicaulis var crassicaulis	Pacific sanicle	19	100	2	35
Silene scouleri ssp grandis	Scouler's catchfly	1	100	+	2
Trifolium willdenowii	tomcat clover	+	50	0	+
Vicia americana ssp americana	American vetch	3	50	0	3
Vicia hirsuta	hairy vetch	+	100	+	+
Vicia sativa	common vetch	1	100	+	1
Zigadenus venenosus var venenosus	meadow death camas	2	50	0	2
Lichens		1	100	+	1

Site Characteristics of Golden Paintbrush Populations

VEGETATION TABLE 10: Alpha Islet (2 plots)

Kartesz 2003 Name	Common Name	Cover	Constancy	min	max
Moss		32	100	4	60
Rock		+	50	0	+

VEGETATION TABLE 11: Trial Island (3 plots)

Kartesz 2003 Name	Common Name	Cover	Constancy	min	max
Shrubs, Subshrubs, Woody Vines					
		8	100	3	15
Mahonia aquifolium	tall Oregongrape	4	100	2	7
Rosa nutkana	nootka rose	1	100	1	2
Rubus ursinus ssp macropetalus	trailing blackberry	1	67	0	1
Symphoricarpos albus var laevigatus	common snowberry	6	67	0	8
Graminoids					
		12	100	10	15
Agrostis spp	bentgrass	+	33	0	+
Aira praecox	early hairgrass	2	67	0	3
Anthoxanthum odoratum	sweet vernalgrass	3	67	0	4
Bromus carinatus	California brome	+	33	0	+
Bromus hordeaceus	soft brome	+	33	0	+
Carex rossii	Ross's sedge	+	67	0	+
Dactylis glomerata	orchard grass	+	33	0	+
Danthonia californica	California danthonia	+	67	0	+
Elymus glaucus	blue wildrye	3	33	0	3
Vulpia bromoides	barren fescue	7	33	0	7
Festuca rubra	red fescue	5	67	0	6
Luzula comosa	Pacific wood-rush	+	100	+	+
Poa bulbosa	bulbous bluegrass	+	33	0	+
Poa confinis	coastline bluegrass	+	33	0	+
Poa pratensis	Kentucky bluegrass	3	100	+	8
Forbs and Ferns					
		55	100	50	60
Achillea millefolium var occidentalis	yarrow	+	67	0	+
Allium acuminatum	Hooker's onion	1	33	0	1
Triteleia hyacinthina	hyacinth brodiaea	3	67	0	4
Camassia leichtlinii ssp suksdorfii	great camas	17	100	+	30
Camassia quamash	common camas	20	33	0	20
Castilleja levisecta	golden paintbrush	3	100	1	5
Cerastium arvense ssp strictum	field chickweed	+	100	+	+
Dodecatheon pulchellum	handsome shooting star	+	33	0	+
Eriophyllum lanatum var lanatum	woolly sunflower	1	33	0	1
Fragaria virginiana ssp platypetala	common strawberry	+	33	0	+
Fritillaria affinis var affinis	chocolate lily	1	100	1	2
Galium aparine	cleavers	+	33	0	+
Grindelia stricta var stricta	Oregon gumweed	+	33	0	+
Hypochaeris radicata	hairy cat's-ear	3	67	0	4
Lomatium nudicaule	bare-stem lomatium	15	100	5	20
Lomatium utriculatum	spring-gold	2	100	+	5
Orobanche uniflora	naked broomrape	+	33	0	+
Plantago lanceolata	English plantain	8	100	1	20
Pteridium aquilinum var pubescens	bracken fern	2	33	0	2

Site Characteristics of Golden Paintbrush Populations

VEGETATION TABLE 11: Trial Island (3 plots)

Kartesz 2003 Name	Common Name	Cover	Constancy	min	max
Rumex acetosella	sheep sorrel	+	100	+	+
Sanicula arctopoides	bear's foot sanicle	+	33	0	+
Sanicula crassicaulis var crassicaulis	Pacific sanicle	3	67	0	4
Sherardia arvensis	blue field-madder	+	33	0	+
Vicia hirsuta	hairy vetch	1	67	0	2
Vicia sativa	common vetch	2	100	+	4
Zigadenus venenosus var venenosus	meadow death camas	3	33	0	3
Lichens		4	100	+	9
Moss		10	100	4	20
Bare Soil		+	33	0	+

VEGETATION TABLE 12: Whidbey Coastal Prairie (5 plots)

Kartesz 2003 Name	Common Name	Cover	Constancy	min	max
Shrubs, Subshrubs, Woody Vines		6	100	2	15
Mahonia aquifolium	tall Oregongrape	1	40	0	1
Rosa nutkana	nootka rose	4	80	0	9
Rubus ursinus ssp macropetalus	trailing blackberry	3	80	0	6
Graminoids		70	100	55	85
Agrostis spp	bentgrass	8	20	0	8
Aira caryophyllea	silver hairgrass	+	40	0	+
Anthoxanthum odoratum	sweet vernalgrass	8	60	0	10
Bromus carinatus	California brome	6	80	0	15
Bromus hordeaceus	soft brome	1	20	0	1
Carex rossii	Ross's sedge	+	20	0	+
Carex tumulicola	foothill sedge	33	80	0	50
Dactylis glomerata	orchard grass	6	80	0	20
Schedonorus phoenix	tall fescue	1	20	0	1
Vulpia bromoides	barren fescue	+	20	0	+
Festuca rubra	red fescue	14	80	0	20
Holcus lanatus	common velvet grass	5	80	0	10
Lolium perenne	perennial ryegrass				
Luzula comosa	Pacific wood-rush	0	80	0	1
Poa pratensis	Kentucky bluegrass	19	100	3	55
Forbs and Ferns		50	100	30	70
Achillea millefolium var occidentalis	yarrow	2	100	+	3
Anthriscus caucalis	bur chervil	+	20	0	+
Castilleja levisecta	golden paintbrush	2	100	+	4
Castilleja miniata	scarlet paintbrush	+	20	0	+
Cerastium glomeratum	sticky chickweed	+	20	0	+
Cirsium arvense	Canada thistle	1	20	0	1
Cirsium brevistylum	short-styled thistle	+	20	0	+
Cirsium vulgare	bull thistle	1	40	0	1
Daucus carota	Queen Anne's lace	2	80	0	4
Erigeron speciosus var speciosus	showy fleabane	+	40	0	+
Fragaria vesca ssp bracteata	woods strawberry	3	20	0	3
Fragaria virginiana ssp platypetala	common strawberry	15	20	0	15
Fritillaria affinis var affinis	chocolate lily	1	20	0	1
Galium aparine	cleavers	+	20	0	+
Geranium dissectum	cut-leaf geranium	+	20	0	+
Heracleum maximum	cow-parsnip	8	40	0	15
Hypochaeris radicata	hairy cat's-ear	1	60	0	1
Lomatium nudicaule	bare-stem lomatium	+	20	0	+
Myosotis discolor	yellow-and-blue forget-me-not	+	60	0	+
Plantago lanceolata	English plantain	11	100	8	15
Pteridium aquilinum var pubescens	bracken fern	3	40	0	5

Site Characteristics of Golden Paintbrush Populations

VEGETATION TABLE 12: Whidbey Coastal Prairie (5 plots)					
Kartesz 2003 Name	Common Name	Cover	Constancy	min	max
Ranunculus occidentalis var occidentalis	western buttercup	1	20	0	1
Rumex acetosella	sheep sorrel	1	60	0	1
Sanicula crassicaulis var crassicaulis	Pacific sanicle	13	100	1	35
Solidago canadensis var salebrosa	Canadian goldenrod	7	60	0	20
Taraxacum officinale	common dandelion	1	100	+	3
Trifolium dubium	suckling clover	2	80	0	3
Trifolium repens	white clover	+	40	0	+
Vicia americana ssp americana	American vetch	3	20	0	3
Vicia villosa	woolly vetch	6	40	0	10
Vicia hirsuta	hairy vetch	3	100	1	5
Vicia sativa	common vetch	3	100	+	10
Moss		33	40	0	35

VEGETATION TABLE 13: Whidbey Bluff Habitat (2 plots)					
Kartesz 2003 Name	Common Name	Cover	Constancy	min	max
Shrubs, Subshrubs, Woody Vines		3	100	+	5
Mahonia aquifolium	tall Oregongrape	5	50	0	5
Rosa nutkana	nootka rose	+	50	0	+
Graminoids		55	100	50	60
Aira caryophylla	silver hairgrass	+	100	+	+
Bromus carinatus	California brome	1	50	0	1
Bromus hordeaceus	soft brome	4	100	+	8
Bromus rigidus	rip-gut brome	16	100	2	30
Dactylis glomerata	orchard grass	1	50	0	1
Vulpia bromoides	barren fescue	3	50	0	3
Festuca rubra	red fescue	33	100	30	35
Koeleria macrantha	prairie junegrass	+	50	0	+
Leymus mollis ssp mollis	dune wildrye	+	50	0	+
Luzula comosa	Pacific wood-rush	1	50	0	1
Poa pratensis	Kentucky bluegrass	1	100	+	2
Forbs and Ferns		23	100	20	25
Achillea millefolium var occidentalis	yarrow	3	100	1	4
Artemisia campestris ssp borealis var scouleriana	northern wormwood	1	50	0	1
Castilleja levisecta	golden paintbrush	2	100	+	3
Castilleja miniata	scarlet paintbrush	+	50	0	+
Cerastium arvense ssp strictum	field chickweed	3	50	0	3
Daucus carota	Queen Anne's lace	+	50	0	+
Eriophyllum lanatum var lanatum	woolly sunflower	1	50	0	1
Erigeron speciosus var speciosus	showy fleabane	2	50	0	2
Grindelia stricta var stricta	Oregon gumweed	1	100	+	1
Hypochaeris radicata	hairy cat's-ear	1	100	+	1
Lomatium nudicaule	bare-stem lomatium	15	50	0	15
Lomatium utriculatum	spring-gold	+	50	0	+
Lupinus densiflorus var densiflorus	dense-flowered lupine	2	50	0	2
Lupinus littoralis	seashore lupine	4	50	0	4
Plantago lanceolata	English plantain	8	100	8	8
Pteridium aquilinum var pubescens	bracken fern	1	50	0	1
Rumex acetosella	sheep sorrel	6	50	0	6
Sanicula crassicaulis var crassicaulis	Pacific sanicle	5	50	0	5
Silene menziesii ssp menziesii	white catchfly	+	50	0	+
Solidago canadensis var salebrosa	Canadian goldenrod	2	50	0	2
Sonchus spp	sow-thistle	+	50	0	+
Taraxacum officinale	common dandelion	+	50	0	+
Trifolium dubium	suckling clover	+	50	0	+
Vicia hirsuta	hairy vetch	+	100	+	+
Vicia sativa	common vetch	+	100	+	+

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Moss		1	50	0	1
Bare Soil		6	100	2	10

VEGETATION TABLE 5: Northern Shallow Soiled islands (5 plots)

Kartesz 2003 Name	Common Name	Cover	Constancy	min	max
Shrubs, Subshrubs, Woody Vines		7	100	2	15
Mahonia aquifolium	tall Oregongrape	4	80	0	7
Rosa nutkana	nootka rose	1	100	1	2
Rubus ursinus ssp macropetalus	trailing blackberry	1	80	0	2
Symphoricarpos albus var laevigatus	common snowberry	6	40	0	8
Graminoids		11	100	6	15
Agrostis spp	bentgrass	+	20	0	+
Aira praecox	early hairgrass	2	40	0	3
Anthoxanthum odoratum	sweet vernalgrass	3	40	0	4
Bromus carinatus	California brome	+	20	0	+
Bromus hordeaceus	soft brome	+	20	0	+
Carex rossii	Ross's sedge	+	60	0	+
Cynosurus echinatus	hedgehog dogtail	+	20	0	+
Dactylis glomerata	orchard grass	+	40	0	+
Danthonia californica	California danthonia	+	40	0	+
Deschampsia caespitosa	tufted hairgrass	4	40	0	6
Elymus glaucus	blue wildrye	3	20	0	3
Vulpia bromoides	barren fescue	7	20	0	7
Festuca rubra	red fescue	8	60	0	15
Holcus lanatus	common velvet grass	+	20	0	+
Luzula comosa	Pacific wood-rush	0	100	+	1
Poa bulbosa	bulbous bluegrass	+	20	0	+
Poa confinis	coastline bluegrass	+	20	0	+
Poa pratensis	Kentucky bluegrass	2	100	+	8
Forbs and Ferns		55	100	50	60
Achillea millefolium var occidentalis	yarrow	+	80	0	+
Allium acuminatum	Hooker's onion	1	40	0	1
Triteleia hyacinthina	hyacinth brodiaea	2	60	0	4
Camassia leichtlinii ssp suksdorfii	great camas	15	100	+	30
Camassia quamash	common camas	20	20	0	20
Castilleja levisecta	golden paintbrush	4	100	1	6
Cerastium arvense ssp strictum	field chickweed	1	100	+	1
Dodecatheon pulchellum	handsome shooting star	+	20	0	+
Eriophyllum lanatum var lanatum	woolly sunflower	1	20	0	1
Fragaria virginiana ssp platypetala	common strawberry	5	40	0	9
Fritillaria affinis var affinis	chocolate lily	1	100	+	3
Galium aparine	cleavers	+	20	0	+
Grindelia stricta var stricta	Oregon gumweed	+	40	0	+
Hypochaeris radicata	hairy cat's-ear	3	80	0	4
Lomatium dissectum var dissectum	fern-leaved lomatium	1	20	0	1
Lomatium nudicaule	bare-stem lomatium	9	100	+	20
Lomatium utriculatum	spring-gold	2	60	0	5

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VEGETATION TABLE 5: Northern Shallow Soiled islands (5 plots)					
Kartesz 2003 Name	Common Name	Cover	Constancy	min	max
Lotus micranthus	small-flowered deervetch	2	20	0	2
Lupinus bicolor ssp bicolor	two-colored lupine	+	20	0	+
Orobanche uniflora	naked broomrape	+	20	0	+
Plantago lanceolata	English plantain	8	60	0	20
Pteridium aquilinum var pubescens	bracken fern	11	40	0	20
Ranunculus californicus	California buttercup	1	40	0	1
Rumex acetosella	sheep sorrel	0	100	+	1
Sanicula arctopoides	bear's foot sanicle	+	20	0	+
Sanicula bipinnatifida	purple sanicle	+	20	0	+
Sanicula crassicaulis var crassicaulis	Pacific sanicle	11	80	0	35
Sherardia arvensis	blue field-madder	+	20	0	+
Silene scouleri ssp grandis	Scouler's catchfly	1	40	0	2
Trifolium willdenowii	tomcat clover	+	20	0	+
Vicia americana ssp americana	American vetch	3	20	0	3
Vicia hirsuta	hairy vetch	1	80	0	2
Vicia sativa	common vetch	1	100	+	4
Zigadenus venenosus var venenosus	meadow death camas	3	40	0	3
Lichens		3	100	+	9
Moss		19	100	4	60
Rock		+	20	0	+
Bare Soil		+	20	0	+

5.3. Soils analysis

Table 1 summarizes the results of the soils analyses of eight U.S. sites. Table 2 summarizes the results of soils analyses of Trial Island (Lawrence, unpublished data, 2004).

Site	% organic matter	ppm phosphorus weak bray	ppm Potassium	ppm Magnesium	ppm Calcium	ppm Sodium
Rocky Main Swale	12.9	12	63	54	560	27
Rocky South	16.6	18	91	55	669	21
Rocky East	18.3	16	58	8	302	14
Ft Casey	12.4	5	378	609	1564	122
Ft. Casey North	8.5	5	142	696	1215	164
Bocker Central	7.4	7	38	253	720	55
Ebey's East	1.9	6	70	366	407	61
Ebey's Center	1.5	6	108	325	297	58
Ebey's West	1.6	17	98	425	503	87
West Beach	5.5	8	108	229	535	43
Forbes SE	5.5	7	189	538	1187	87
Forbes NW	4.3	17	145	258	751	52
Long Island A	24.4	11	100	274	659	100
Long Island B	21.2	6	162	596	2405	180
Long island C	18.7	9	75	299	807	84
False-Subpop. #1	7.5	6	170	725	1110	131
False-Subpop. #2	22.8	5	108	311	3412	32
False-Subpop. #3	5.9	11	178	312	922	52
San Juan-Pecan	14.7	6	125	420	1830	53
San Juan Ditch	15	4	44	445	1528	42

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SOILS ANALYSES TABLE 1.2 (A & L Western Agricultural Labs)						
Site	pH	buffer index	meq/100g Hydrogen	%K	%Mg	%Ca
Rocky Main Swale	5.5	5.7	1.2	3.4	9.3	58.8
Rocky South	5.5	5.6	1.4	4.2	8.1	60.1
Rocky East	5.3	5.3	0.8	5.8	2.6	58.3
Ft Casey	6.1	6.4	2.3	5.8	30.1	46.9
Ft. Casey North	6.1	6.5	2.1	2.4	38.3	40.5
Bocker Central	5.7	6.2	1.6	1.3	27.4	47.2
Ebey's East	6.1	7	0.9	2.8	47.2	31.8
Ebey's Center	6.4	7.2	0.5	5.4	52	28.8
Ebey's West	6.4	6.9	0.7	3.5	47.9	34.4
West Beach	5.5	6.3	1.8	4.1	27.8	39.4
Forbes SE	6.1	6.6	1.8	3.7	33.9	45.4
Forbes NW	5.7	6.6	1.7	4.5	25.9	45.8
Long Island A	5.2	5.6	3.3	2.7	23.7	34.5
Long Island B	6.1	6.2	2.9	2	233	57
Long island C	5.3	5.9	3.2	1.9	24.1	39.5
False-Subpop. #1	6.1	6.7	2	3	41	38.1
False-Subpop. #2	6.5	6.9	1.6	1.3	11.8	78.7
False-Subpop. #3	5.6	6.2	2.4	4.4	25	44.8
San Juan-Pecan	5.6	6.1	4	1.9	20.1	53.2
San Juan Ditch	6.4	6.7	1.1	0.9	28.8	59

Site Characteristics of Golden Paintbrush Populations

SOILS ANALYSES TABLE 1.3 (A & L Western Agricultural Labs)					
Site	%NA	ppm Nitrogen	ppm Zinc	ppm manganese	ppm Iron
Rocky Main Swale	2.4	9	0.6	2	7
Rocky South	1.6	9	1.5	5	26
Rocky East	2.1	5	1.9	2	10
Ft Casey	3.2	10	3.9	3	105
Ft. Casey North	4.8	4	3.5	5	110
Bocker Central	3.1	4	1.5	2	92
Ebey's East	4.2	27	0.7	2	40
Ebey's Center	4.9	6	0.4	1	21
Ebey's West	5.2	8	0.2	1	46
West Beach	2.8	7	1.2	2	93
Forbes SE	2.9	9	6.3	2	143
Forbes NW	2.8	14	1	1	89
Long Island A	4.6	10	9.7	6	80
Long Island B	3.7	31	1.8	5	50
Long island C	3.6	4	1.4	2	38
False-Subpop. #1	3.9	4	26.4	2	66
False-Subpop. #2	0.6	29	1	1	36
False-Subpop. #3	2.2	8	2.8	2	99
San Juan-Pecan	1.3	22	1.3	1	49
San Juan Ditch	1.4	5	0.6	1	98

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SOILS ANALYSES TABLE 1.4 (A & L Western Agricultural Labs)						
Site	ppm Boron	mmhos/cm Soluble Salts	% sand	%silt	%clay	texture
Rocky Main Swale	0.4	0.2	83	10	7	loamy sand
Rocky South	0.6	0.6	77	16	7	loamy sand
Rocky East	0.5	0.6	77	16	7	loamy sand
Ft Casey	1.2	0.5	73	20	7	loamy sand
Ft. Casey North	1.2	0.7	65	24	11	sandy loam
Bocker Central	0.7	0.6	69	22	9	sandy loam
Ebey's East	0.3	0.5	91	4	5	sand
Ebey's Center	0.2	0.4	89	6	5	sand
Ebey's West	0.4	1	83	10	7	loamy sand
West Beach	0.3	0.5	71	20	9	loamy sand
Forbes SE	0.4	0.4	43	30	27	clay loam
Forbes NW	0.5	0.6	61	24	15	sandy loam
Long Island A	0.8	0.8	69	18	13	sandy loam
Long Island B	1.5	0.5	77	14	9	loamy sand
Long island C	0.9	0.9	73	20	7	loamy sand
False-Subpop. #1	0.8	0.9	51	24	25	sandy clay loam
False-Subpop. #2	1.5	0.6	74	18	8	loamy sand
False-Subpop. #3	0.5	0.6	61	22	17	sandy loam
San Juan-Pecan	0.8	0.5	69	22	9	sandy loam
San Juan Ditch	0.7	0.6	59	24	17	sandy loam

SOILS ANALYSES TABLE 2.1 (B. Lawrence, 2004, unpublished data)

ID	sample number	pH	mg NH ₄ /kg soil	mg NO ₃ /kg soil	Extractable C ug C/g soil	Extractable TN ug/g soil	OM	K (µg/g soil)	P(µg/g soil)
Trial A	1	5.53	15.68	6.58	110.16	19.79	18.36	934.7	483.3
Trial A	2	5.58	15.64	6.59	116.50	20.11	16.91	867.2	439.2
Trial B	1	5.55	12.13	3.54	104.72	15.63	14.41	838.3	412.5
Trial B	2	5.58	11.76	3.29	97.63	14.81	15.66	963.2	504.8
Trial C	1	5.38	14.76	1.64	93.73	14.98	11.21	1135	428.2
Trial C	2	5.39	13.88	1.60	91.26	14.54	13.19	971.5	380.6
Trial D	1	5.90	12.72	3.75	140.99	22.33	17.42	1244	505
Trial D	2	5.88	12.02	4.12	151.35	20.20	17.29	1307	521.9

SOILS ANALYSES TABLE 2.2 (B. Lawrence, 2004, unpublished data)

ID	sample number	S (µg/g soil)	Mg (µg/g soil)	Mn (µg/g soil)	%sand	%silt	% clay	texture (USDA classification)
Trial A	1	435.5	3140	590.8	38.4	47.5	14.1	loam
Trial A	2	409.2	3099	552.7				
Trial B	1	408.8	2635	533	60.5	28.9	10.7	sandy loam
Trial B	2	531	2975	682				
Trial C	1	324.4	3101	497.8	65.6	28.8	5.6	sandy loam
Trial C	2	303.2	3366	470.6				
Trial D	1	525.9	3345	530.3	60.5	27.2	12.4	sandy loam
Trial D	2	541.1	3821	547.8				

6. PHOTOS OF SITES



Rocky Prairie



Ft Casey (bluff)



Ebey's Bluff



Bocker



West Beach



Forbes Point

Site Characteristics of Golden Paintbrush Populations



Long Island



False Bay-
Subpop. #1



False Bay- Subpop. #2



San Juan Valley



Alpha Islet



Trial Island

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