Habitat sampling at Fir Butte, Greenhill, Oxbow West, and Vinci

2010 Report

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PREFACE

This report is the result of a cooperative Challenge Cost Share project between the Institute for Applied Ecology (IAE) and a federal agency. IAE is a non-profit organization whose mission is conservation of native ecosystems through restoration, research and education. Our aim is to provide a service to public and private agencies and individuals by developing and communicating information on ecosystems, species, and effective management strategies and by conducting research, monitoring, and experiments. IAE offers educational opportunities through 3-4 month internships.

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INTRODUCTION

The West Eugene Wetlands (WEW) Project is a cooperative venture by the Bureau of Land Management, Eugene District, and others to protect and restore wetland ecosystems in the southern Willamette Valley of Oregon. This unique program involves a partnership between federal, state, and local agencies and organizations to manage lands and resources in an urban area for multiple public benefits. In 2005, the BLM developed a long term (10 year) land management implementation schedule for its parcels within the West Eugene Wetlands project area. This 10 year Environmental Assessment (EA) schedule outlines targets for habitat conditions and provides guidance on the priority of work for maintenance, enhancement, and restoration projects (BLM 2005). Within the EA, each parcel will be monitored to meet four habitat management targets. In general, these habitat targets include the following: (1) prevent woody vegetation encroachment, (2) prevent invasive plant spread, (3) prevent litter and thatch build up, and (4) maintain existing levels of native plant species diversity. When monitoring indicates that these targets are not being met based on the established thresholds, management actions may be triggered (further outlined in the EA NO. 0R090-0503, Alternative D, pages 58-61). In addition, many of these sites provide habitat for species listed in Recovery Plan for Threatened and Endangered Species in Western Oregon and Southwest Washington (USFWS 2010).

The purpose of this project was to conduct monitoring at several sites in the West Eugene Wetlands to assess whether they were within the habitat guidelines. In 2010, we monitored four sites: Fir Butte (2 plots), Greenhill (2 plots), Oxbow West wet prairie (1 plot), and Vinci (2 plots). With the exception of Greenhill, monitoring previously occurred at these sites in 2007.

Sites

Fir Butte

Fir Butte is an 18 acre prairie remnant owned by the Eugene District BLM. This site has been heavily invaded by many exotic weeds including *Rubus armeniacus, Cytisus scoparius, Centaurea pratensis*, and *Arrhenatherum elatius*. Despite the relatively poor habitat quality, one of the largest known extant populations of *Lupinus sulphureus* ssp. *kincaidii* occurs here. This site also supports a relatively large population of the endangered Fender's blue butterfly (*Icaricia icarioides fenderi*). *Lupinus sulphureus ssp. kincaidii* serves as the obligate host plant for *I. icarioides fenderi*. Since 1999, BLM crews have made substantial efforts to control *Centaurea pratensis* and *Cytisus scoparius*, and selected areas have been repeatedly mowed to reduce the invasion of *R. armeniacus*. Since 2001, experimental treatment plots at the site have been mowed and/or burned. Monitoring in the northeast and southwest occurred in 2007 and 2010. Monitoring in the southeast occurred in 2009 and is scheduled to be repeated in 2012.

Greenhill

Greenhill is a mix of high quality remnant wet prairie, ash swale, upland prairie and oak woodland. Monitoring occurred in the remnant wet prairie with a population of *Lomatium bradshawii.* The area has variable microtopography, and supports species adapted to living across the hydrological range of seasonally flooded lowlands to dry uplands. The remnant prairie is adjacent to a restored area that has had reintroductions of *Horkelia congesta*, *Sericocarpus rigidus*, *Erigeron decumbens,* and *Lomatium bradshawii*.

Oxbow West

The overall habitat quality of the remnant prairie at Oxbow West is good, and ongoing management efforts have helped reduce encroachment by woody species including *Pyrus communis*, *Fraxinus latifolia*, *Populus trichocarpa*, and other shrubs. Efforts are also being made to eradicate *Phalaris arundinacea,* an invasive graminoid that is expanding into the prairie from adjacent wet areas. Oxbow West supports a number of rare species, including *Erigeron decumbens*, *Lupinus sulphureus* ssp. *kincaidii*, *Cicendia quadrangularis*, and *Sidalcea cusickii*. The habitat has also been noted as having high potential for reintroduction of *Lomatium bradshawii*. The federally endangered *E. decumbens* is the most abundant rare plant at Oxbow West, occupying approximately five acres. Maintaining and improving the prairie habitat is the main objective for management at Oxbow West. Management treatments in the wet prairie (occupied by *E. decumbens*) have included mowing (initiated in 2002) and burning (treated in September 2005). Monitoring of the wet prairie habitat occurred in 2007 and 2010. Monitoring of the upland prairie habitat occupied by *L. sulphureus* ssp. *kincaidii* occurred in 2009 and is scheduled to be repeated in 2012.

Vinci

Vinci is a relatively large parcel containing both wet prairie and vernal pool habitats. Although the quality of the site is relatively high, it has been invaded by woody species such as *Pyrus communis, Fraxinus latifolia*, *Populus trichocarpa* and exotic herbaceous species including *Phalaris arundinacea* and *Dipsacus fullonum*. Vinci supports a number of rare species, including *Erigeron decumbens*, *Sericocarpus rigidus*, and *Horkelia congesta* ssp. *congesta*. Monitoring of the wet prairie habitat occurred in 2007 and 2010. Upland prairie habitat was monitored in 2009, and is scheduled to be repeated in 2012.

METHODS

The point-intercept sampling method was selected for this project because it provides an unbiased quantitative description of plant communities in an efficient manner (City of Eugene 1997). Although some species with less than 0.5% cover were likely missed, this method provides a consistent manner in which to efficiently sample a large area.

In July 2010, seven plots were sampled to estimate vegetation cover in the West Eugene Wetlands; Fir Butte, Greenhill, and Vinci each contained two plots and Oxbow West contained one plot (Figure 1). Plot dimensions varied by site and were based on established infrastructure (e.g. conduit or other permanent markers). The sampling scheme at each site was selected so that (1) the maximum amount of habitat would be sampled, and (2) there would be at least 200 points per plot (Table 1). The origin was placed in the southeast corner of each plot (Figure 2). For Oxbow West, Fir Butte 1, Fir Butte 2 and Vinci 2, the first transect running perpendicular to the baseline was randomly located between 0m and 4m. Subsequent transects were placed every 4m along the baseline. The first sample point along each transect was randomly located between 0m and 5m, and systematically located every 5m. Vinci 1 followed similar protocol for perpendicular transect placement. However, the first sample point along each transect was randomly located between 0m and 4m, and was located every 4m after that. For Greenhill 1, the first transect perpendicular to the baseline was randomly located between 0m and 3m, with transects placed every 3m thereafter. The first point along the transect was randomly located between 0m and 5m, and continued every 5m. For Greenhill 2, the first transect perpendicular to the baseline started randomly between 0m and 5m, and continued every 5m thereafter. The first point along each transect was randomly located between 0m and 3m, with each point located every 3m thereafter.

We used a monopod that utilized a laser light (Synergy Resource Solutions, Inc.) to sample the vegetation at each point. We adjusted the height of the monopod so that it was above the vegetation canopy at every site. At each point, we recorded every species intercepted by the laser light and the nature of the substrate (bare ground, litter, or moss).

Species nomenclature, habit, and native status were obtained from the USDA Plants Database (http://plants.usda.gov). We calculated the percent cover within each plot by totaling the "hits" for each component (each species, growth habit group, and cover type), dividing by the total number of sampling points per plot, and multiplying by 100. The timing of our surveys (July) meant that we missed many early-season species, including some of those that are listed threatened and endangered. In order to document all species at a site, surveys should take place at multiple times throughout the growing season.

Table 1. Characteristics of habitat sampling plots.

Site	Plot origin (UTMs, 10T Nad 27)	Plot dimensions	# samples
Oxbow	See Figure 3	85m x 50m	212
Fir Butte			
Plot 1	See Figure 4	85m x 50m	214
Plot 2	See Figure 4	85m x 50m	214
Greenhill			
Plot 1	483331E, 4878454N	60m x 50m	211
Plot 2	483384E, 4878331N	60m x 50m	200
Vinci			
Plot 1	483712E, 4877465N	65m x 50m	203
Plot 2	483789E, 4877736N	85m x 50m	214

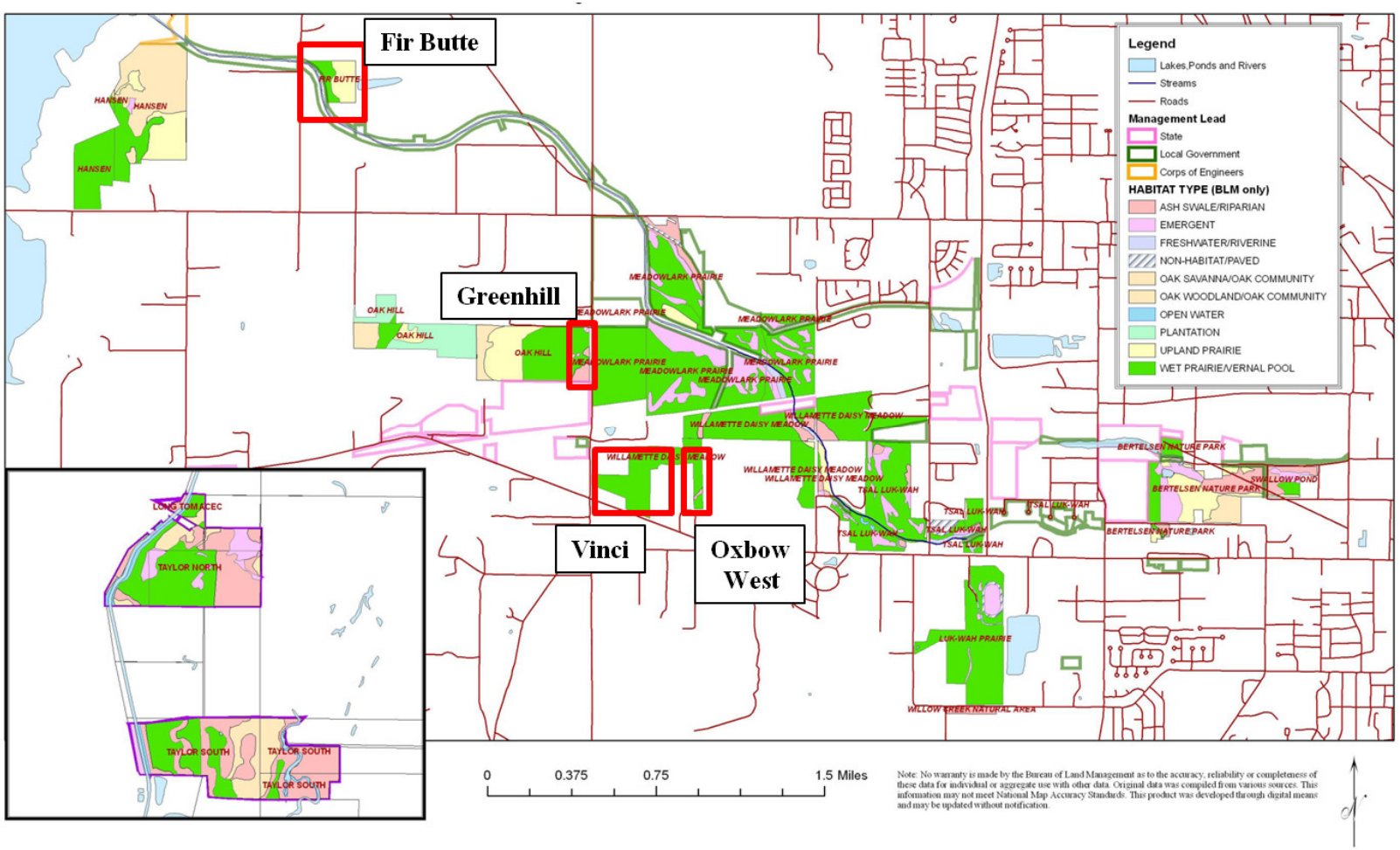

Figure 1 Monitoring sites described in this project (Fir Butte, Greenhill, Oxbow West, and Vinci). Sites are labeled and outlined. Map describes plant communities at these and other sites in the West Eugene Wetlands (USDI BLM 2005).

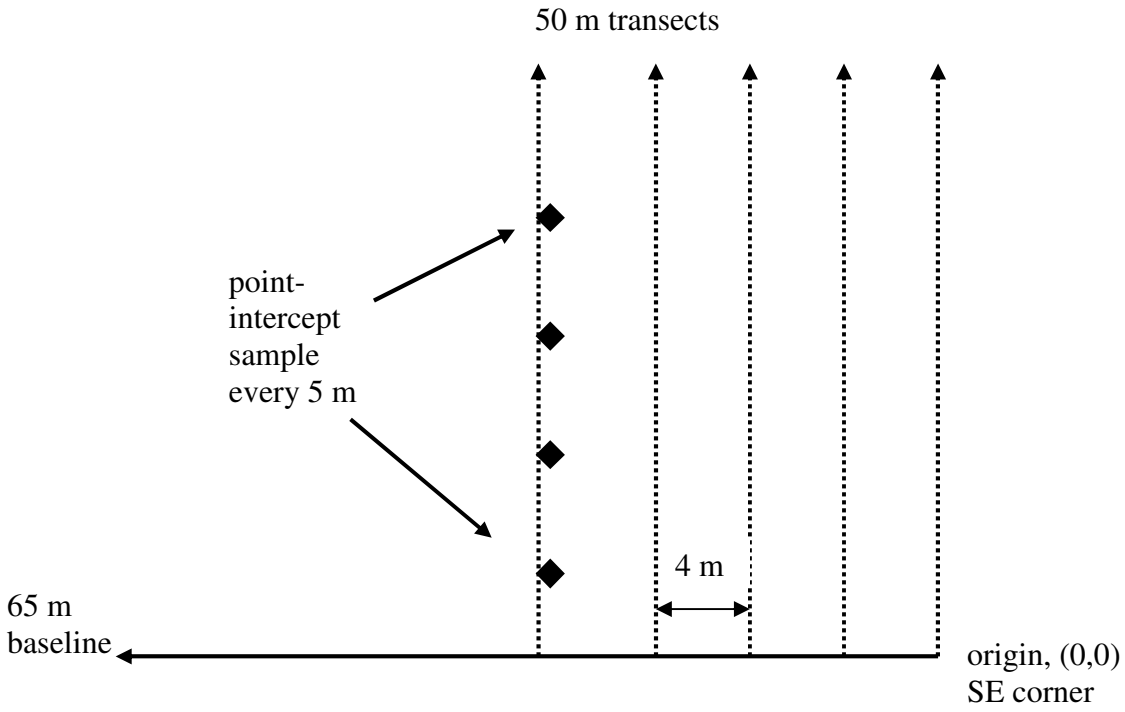

Figure 2 Example design of a sampling plot.

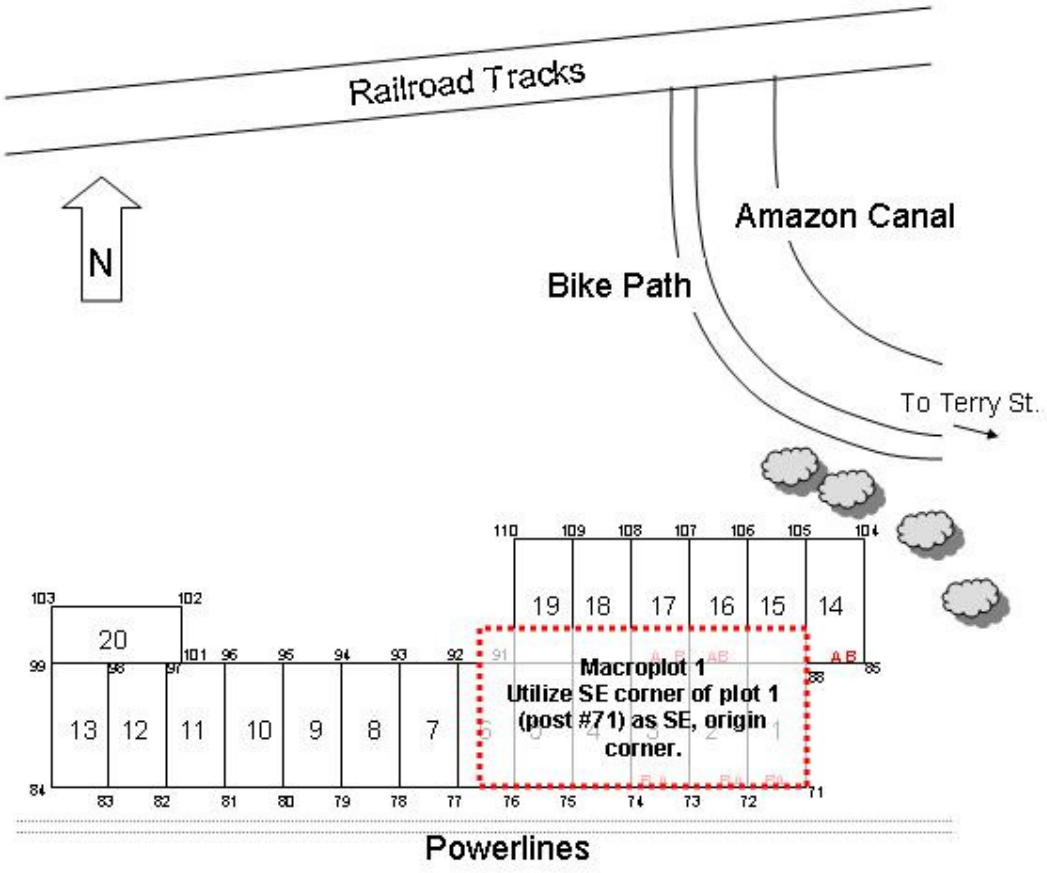

Figure 3 Location of the sampling plot at Oxbow West. Plots in the background (1-20) are for an experiment testing the effectiveness of mowing and burning treatments on *Erigeron decumbens*.

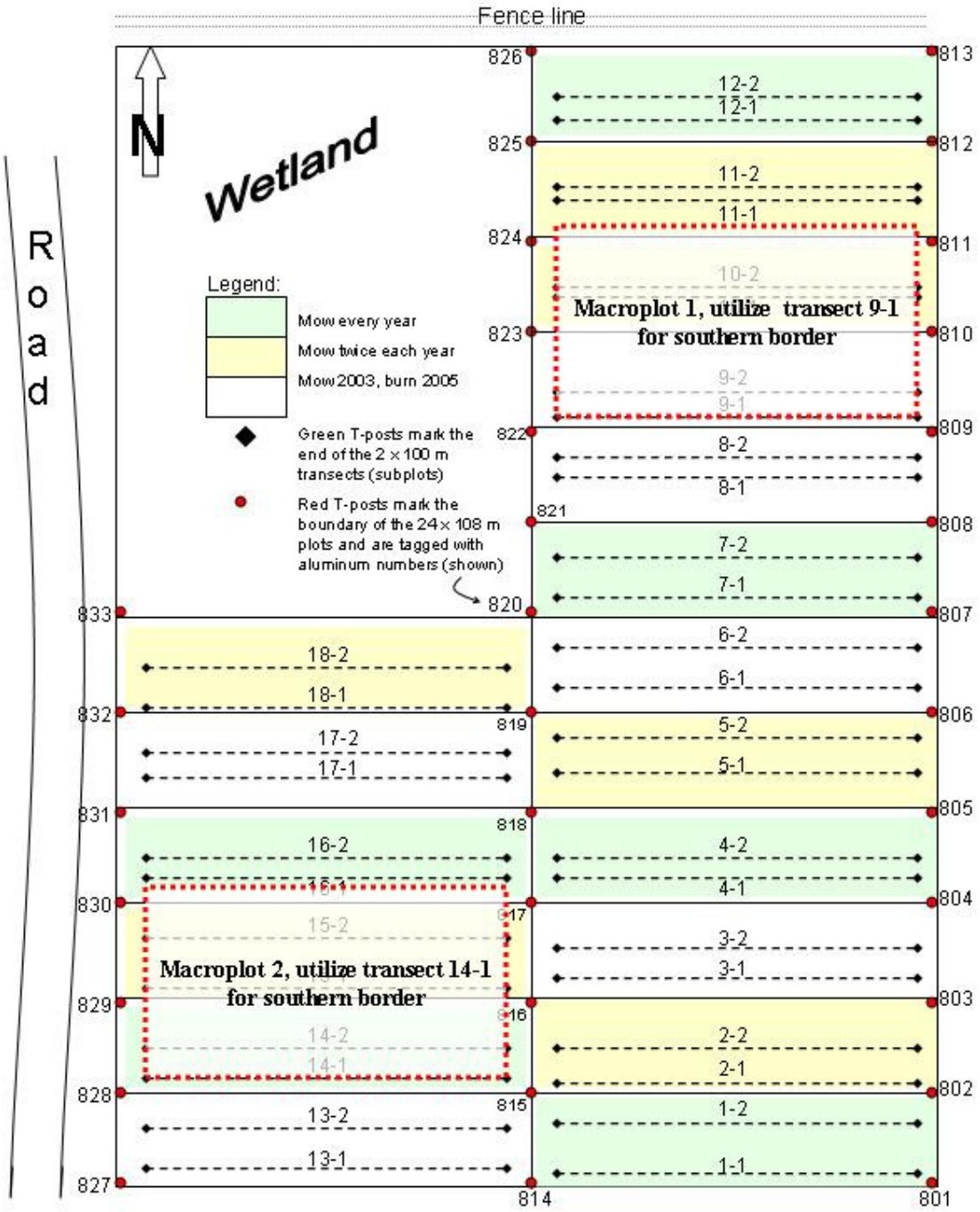

Figure 4 Location of sampling plots at Fir Butte. Plots in the background (1-18) are for an experiment testing the effectiveness of mowing and burning treatments on *Lupinus sulphureus* ssp. *kincaidii*.

RESULTS AND DISCUSSION

Sites

Fir Butte

The plant community at Fir Butte 1 was dominated by introduced species. Of the 17 species found in this plot, two were native, and 15 were introduced. All of the native species were forbs, but the introduced species were forbs (9), graminoids (5) and shrubs (1). No trees were at this site. The combined total of cover of introduced species was four times that of natives (Figure 5). The most abundant species at this plot was the introduced grass *Agrostis capillaris,* which had 82% cover. Other introduced graminoids included *Holcus lanatus* and *Anthoxanthum odoratum* (2.8% each). Two other introduced graminoids had less than 2% combined cover. Introduced forbs included *Plantago lanceolata (*6.1%), *Daucus carota* (5.6%), *Galium aparine* (5.6%), *Vicia sativa* (4.2%), *Parentucellia viscosa* (3.7%), and *Rumex acetosella* (2.3%). The cover of the other introduced forbs totaled less than 3% (Appendix A). *Rubus armeniacus*, the only woody invasive species found here, had low cover (0.5%). Among the native species, *Galium trifidum* had relatively high cover (29.4%). Cover of *Lupinus sulphureus* ssp. *kincaidii* was only 1.4%; this may have been due, in part, to senescence of many of the individuals by the time of monitoring. Establishment of *L. sulphureus* ssp. *kincaidii* and other native species may be hampered by high litter and moss cover (52.8% and 41.6%, respectively; Table 2).

Table 2 Cover of bare ground, litter and moss at study sites in the West Eugene Wetlands.

	Site						
	Fir Butte 1	**Fir Butte 2**	**Greenhill 1**	**Greenhill 2**	**Oxbow**	**Vinci 1**	**Vinci 2**
Bare ground	6.1	3.3	5.7	9.5	0.0	2.0	0.0
Litter	52.8	80.8	89.1	90.5	100.0	94.1	97.2
Moss	41.6	15.9	5.2	0.0	0.0	4.4	2.8

Fir Butte 2 was likewise dominated by introduced species. Twenty-three species were found in this plot, five native and 18 introduced. All the native species were forbs, while introduced species had representatives in several functional groups (10 forbs, 7 graminoids, and 1 shrub). There were no trees in this plot. Nonnative species cover combined to be approximately eight times that of native species (Figure 6). *Agrostis capilliaris* dominated this plot with 76% cover. Other important invasive graminoids included *Anthoxanthum odoratum* (16.4%), *Bromus hordeaceus* (7.9%), *Holcus lanatus* (6.1%), and *Festuca arundinacea* (2.3%). The remaining invasive graminoids had less than 1% combined cover (Appendix A). The dominant invasive forb was *Vicia sativa*, with 29.4% cover. Other nonnative forbs included *Vicia hirsuta* (4.2%), *Crepis capillaris*

(3.3%), *Parentucellia viscosa* (2.3%), and *Geranium dissectum* (1.9%). The remaining nonnative forbs combined for less than 3% cover. The most abundant native forbs were *Achillea millefolium* (14.9%) and *Epilobium ciliatum* (1.4%). The remaining three native forbs comprised less than 3% combined total cover, including the federally threatened *Lupinus sulphureus* ssp. *kincaidii* (0.9%). Litter cover at this site was over 80%, perhaps due to the abundance of nonnative grass species. Moss cover was relatively low (15.9%; Table 2.)

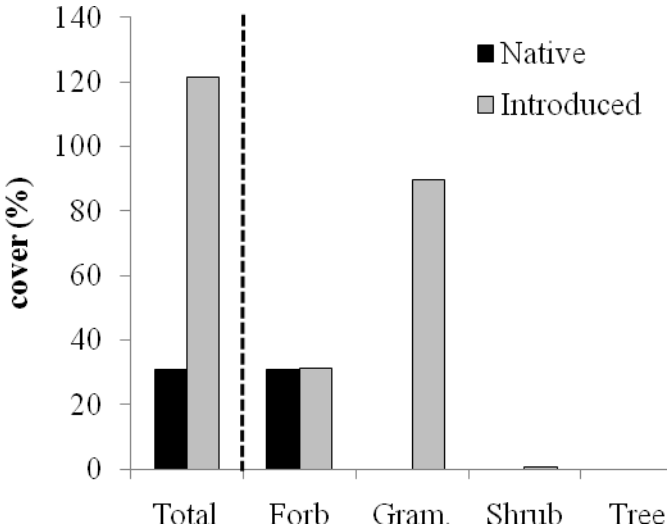

Figure 5 Percent cover of native and introduced species divided into growth habits at **Fir Butte 1.** "Gram." is an abbreviation for graminoids. No tree species were present at this site.

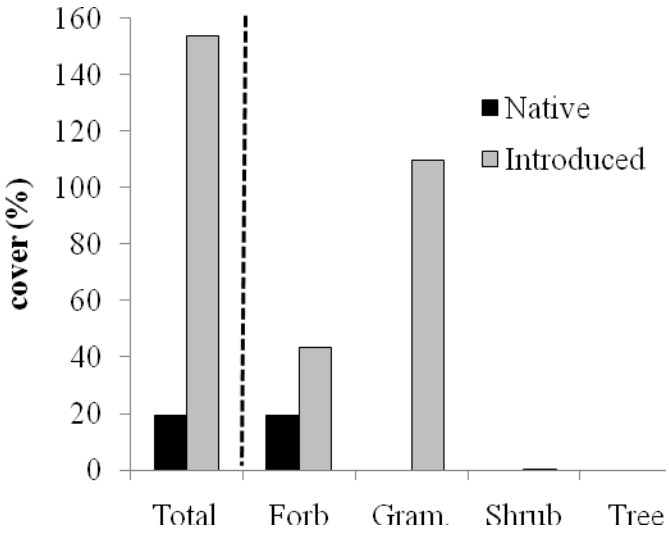

Figure 6 Percent cover of native and introduced species divided into growth habits at **Fir Butte 2.** "Gram." is an abbreviation for graminoids. No tree species were present at this site.

Greenhill

Both richness and cover of native species was higher than that of invasive species at Greenhill 1. The 27 native species were forbs (17), graminoids (7), shrubs (2) and one tree. The 24 nonnative species were forbs (16), graminoids (6), and shrubs (2). Cover by native species at this site was the highest of all sites monitored in 2010 (Figure 7). *Eriophyllum lanatum* was the most abundant native forb (6.2%), followed by *Prunella vulgaris* ssp. *lanceolata* (5.2%), *Microseris laciniata* (4.7%), *Veronica scutellata* (2.8%), *Wyethia angustifolia* (2.8%), and *Madia glomeratus* (1.9%). The remaining 11 forbs had less than 1.5% individual cover, but combined for 7.8% (Appendix A). The most dominant native species at this site was the graminoid *Danthonia californica* (45.5%). Other native graminoids included *Juncus articulatus* (3.3%) and *Festuca roemeri* (1.4%). The other four native graminoids present combined for less than 2.5% cover. The two native shrub species, *Rosa nutkana* and *Toxicodendron diversilobum,* each had 0.5% cover. The lone native tree species, *Fraxinus latifolia*, also had low cover (0.5%). *Vicia hirsuta* was the most abundant nonnative forb (11.4%), followed by *Leontodon taraxacoides* (7.1%), an annual *Cirsium* (4.3%), *Plantago lanceolata* (3.8%), *Myosotis discolor* (2.4%), *Centaurium erythrae* (2.4%) and *Hypericum perforatum* (2.4%). The nine remaining nonnative forbs combined for less than 6.5% cover. *Holcus lanatus* had the highest cover of invasive graminoids (12.8%), followed by *Festuca arundinacea* (8.5%), *Anthoxanthum odoratum* (8.1%), and *Bromus hordeaceus* (3.3%). The other two nonnative graminoids combined for less than 1% cover. Nonnative shrubs were limited to two species with low cover, *Crataegus monogyna* (1%) and *Rubus armeniacus* (0.5%). Litter cover at this site was very high (89.1%; Table 2).

The plot at Greenhill 2 had a near equal number of native and introduced species (20 and 21, respectively), although introduced species cover was almost three times that of native species (Figure 8). Native species were forbs (9), graminoids (8), and woody plants (2 shrubs and 1 tree). Graminoids dominated the native component, and included such species as *Deschampsia cespitosa* (9.0%), *Carex densa* (5.5%), and *Juncus bolanderi* (1.5%). The four other graminoid species had 0.5% cover each (Appendix A). Among native forbs, species with cover greater than 1% included *Prunella vulgaris* ssp. *lanceolata* (3.5%), *Potentilla gracilis* (2.5%), *Wyethia angustifolia* (2.5%) and *Madia glomeratus* (1.5%). All other native forbs had individual cover of 1% or less. Native woody species cover was low, and limited to the shrubs *Rosa nutkana* (2.5%) and *Toxicodendron diversilobum* (1.0%), and the tree *Fraxinus latifolia* (1.0%). Litter cover at this site was also high (90.5%; Table 2).

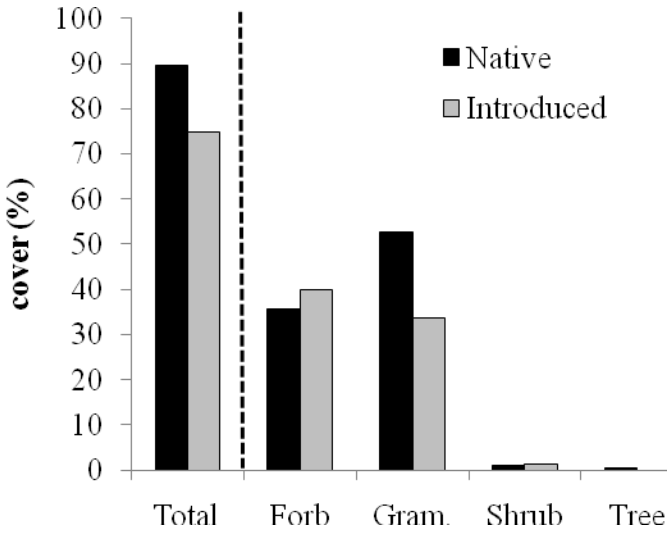

Figure 7 Percent cover of native and introduced species divided into growth habits at **Greenhill 1.** "Gram." is an abbreviation for graminoids.

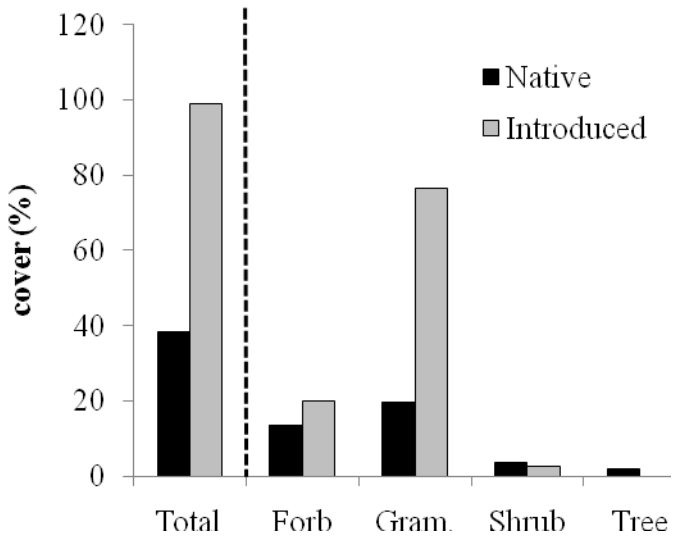

Figure 8 Percent cover of native and introduced species divided into growth habits at **Greenhill 2.** "Gram." is an abbreviation for graminoids.

Oxbow West

Oxbow West had an equal number of native and invasive species. Native species included forbs (4), graminoids (5), and one shrub. Invasive species also included forbs (5), graminoids (4), and one shrub. No trees were found at this site. Native species had higher cover than invasive species (Figure 9), led by the native graminoid *Panicum capillare* with 12.3% cover. Other native graminoids included *Deschampsia cespitosa* (11.3%), *Danthonia californica* (6.1%), and two members of the Juncaceae (combined cover <1.5%; Appendix A). Native forb cover was roughly half of native graminoids (15.6% and 31.6%, respectively), and was composed of *Grindelia integrifolia* (8.5%), *Symphyotrichum hallii* (4.3%), *Prunella vulgaris* ssp. *lanceolata* (2.4%), and an unidentified Asteraceae species (0.5%). The sole native shrub, *Rosa nutkana*, had low cover (0.5%). Graminoids likewise dominated nonnative cover, led by *Anthoxanthum odoratum* (18.9%). The other nonnative graminoids were *Briza minor* (1.0%), *Alopecurus geniculatus* and *Holcus lanatus* (0.5% each). Nonnative forb cover was low; *Leucanthemum vulgare* cover was 2.8%, followed by *Leontodon taraxacoides* (2.4%) and *Plantago lanceolata* (1.9%). *Crepis capillaris* and *Rumex acetosella* had 0.5% cover each. Litter cover at this site was 100% (Table 2).

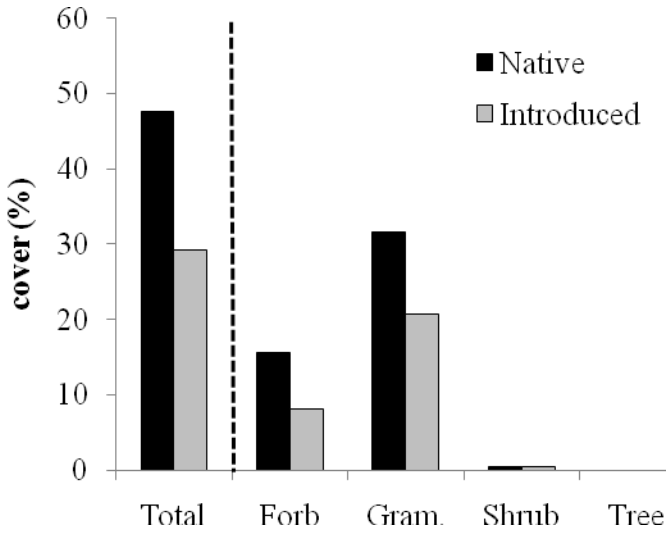

Figure 9 Percent cover of native and introduced species divided into growth habits at **Oxbow West**. "Gram." is an abbreviation for graminoids. No tree species were present at this site.

Vinci

Percent cover by invasive and native species at Vinci 1 was equal and litter cover was very high (94.1%, Figure 10). Of the 18 native species at this plot, there were eight forbs, seven graminoids, one shrub and two trees. Native cover was dominated by graminoids, with 15.8% cover by *Deschampsia cespitosa*. Other native graminoids included *Danthonia californica* (2.0%), *Juncus articulatus* (1.0%) and *Panicum capillare* (1.0%). The remaining three native graminoid species had 0.5% cover each (Appendix A). Among native forbs, *Symphyotrichum hallii* had the highest cover (5.9%), followed by *Grindelia integrifolia* (3.5%), *Galium trifidum* (2.0%), *Madia* sp. (2.0%), *Prunella vulgaris* ssp. *lanceolata* (1.5%) and *Lotus micranthus* (1.0%). *Microseris laciniata* and *Psilocarphus elatior* had 0.5% cover each. The native shrub *Rosa nutkana* had 3.0%. The two native trees, *Fraxinus latifolia* and *Quercus garryana,* had 2.5% and 0.5% cover, respectively. The 13 nonnative species were forbs (8), graminoids (2) and shrubs (3). *Mentha pulegium* had the highest nonnative forb cover (10.8%), followed by *Leucanthemum vulgare* (7.9%), *Leontodon taraxacoides* (2.5%), and *Centaurium erythrae* (1.0%). The other four nonnative forbs had 0.5% cover each. Among nonnative graminoids, *Anthoxanthum odoratum* had the highest cover (11.8%), followed by *Agrostis capillaris* (1.5%). *Rubus armeniacus* was the nonnative shrub with the highest cover (4.9%), followed by *R. laciniatus* (1.0%), and *Rosa eglanteria* (0.5%). Ground cover was almost entirely litter (Table 2).

The plant community at Vinci 2 consisted of 12 native species (9 forbs and 3 graminoids) and 14 nonnative species (7 forbs, 5 graminoids and 2 shrubs). No trees were at this site. Cover by invasive and native species was nearly equal (Figure 11). The native graminoid *Deschampsia cespitosa* had the highest cover of any species (28.5%).

The other native graminoids were *Juncus articulatus* (1.4%) and *Danthonia californica* (0.9%). Native forbs included *Grindelia integrifolia* and *Lotus micranthus* (2.8% each). *Symphyotrichum hallii*, *Prunella vulgaris* ssp. *lanceolata* and an unidentified *Madia* species had 0.9% cover each. The remaining four native forbs had individual cover of 0.5% (Appendix A). Among nonnative forbs, *Leucanthemum vulgare* had the highest cover (7.9%), followed by *Mentha pulegium* (7.0%), and *Centaurium erythrae* (3.7%). *Leontodon taraxacoides* and *Parentucellia viscosa* each had 0.9% cover. *Hypericum perforatum* and *Hypochaeris radicata* had individual cover of 0.5%. *Holcus lanatus* had the highest cover among invasive graminoids (7.0%), followed by *Anthoxanthum odoratum* (4.2%) and *Agrostis capillaris* (1.4%). *Festuca arundinacea* had 0.9% cover, while *Bromus hordeaceus* accounted for 0.5% cover. The invasive shrub *Rubus armeniacus* had 2.8% cover, while *Crataegus monogyna* x *suksdorfii* had 0.9%. Litter in this plot was also very high, perhaps influenced by high graminoid cover (Table 2).

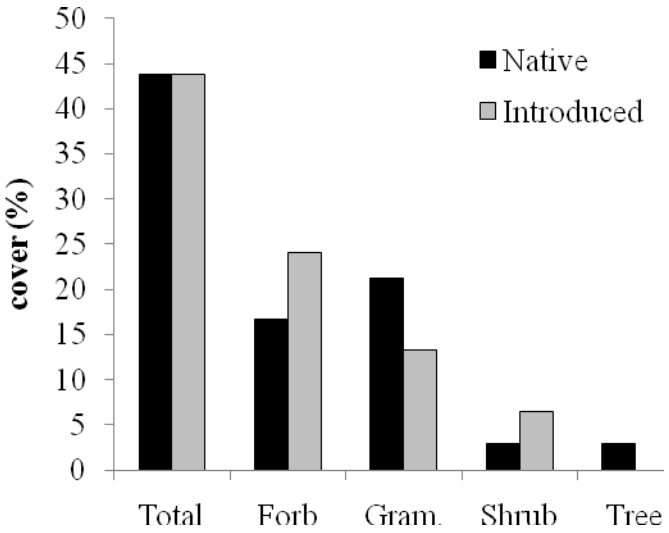

Figure 10 Percent cover of native and introduced species divided into growth habits at **Vinci 1**. "Gram." is an abbreviation for graminoids.

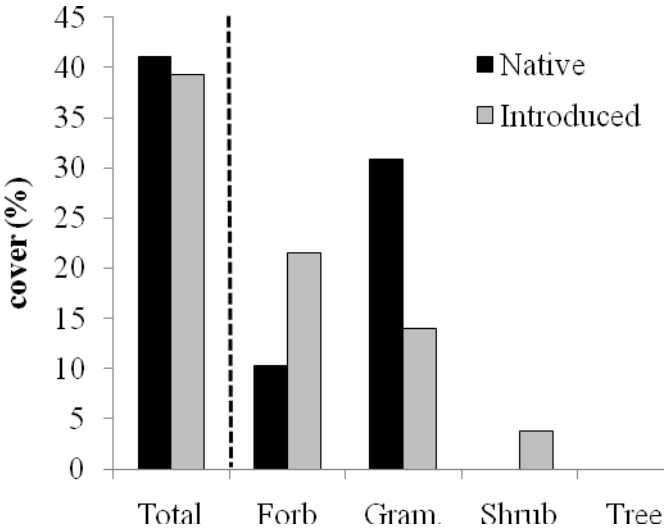

Figure 11 Percent cover of native and introduced species divided into growth habits at **Vinci 2.** "Gram." is an abbreviation for graminoids. No tree species were present at this site.

FENDER'S BLUE BUTTERFLY STEPPING STONE HABITAT

All of the sites monitored in 2010 have the potential to serve as critical habitat for Fender's blue butterfly. Critical habitat for this species includes high quality prairie or oak savannah habitat, the presence of larval host-plants (*Lupinus sulphureus* ssp. *kincaidii*, *L. arbustus*, or *L. albicaulis*), adult nectar sources, and stepping-stone habitat (undeveloped areas with the physical characteristics appropriate for supporting the short-stature prairie oak savannah plant community within 1.2 miles of natal lupine patches) (USFWS 2010). Fir Butte supports relatively large populations of Fender's blue butterfly and *Lupinus sulphureus* ssp. *kincaidii*; however, general habitat quality and abundance of nectar species has not been systematically quantified. Plots at Vinci, Greenhill, and Oxbow West (North) were in areas known to support the endangered *Erigeron decumbens* and/or *Lomatium bradshawii*, but had not yet been surveyed for meeting the criteria for critical habitat for Fender's blue butterfly. Although there is a population of *L. sulphureus* ssp. *kincaidii* at Oxbow West, it is separated from the area of our surveys by several patches of dense shrubs and trees, and a large field dominated by the tall grass *Deschampsia cespitosa*.

All of the sites included in this survey met at least one of the criteria for critical habitat for Fender's blue butterfly. All sites would be suitable stepping stone habitat. *Lupinus sulphureus* ssp. *kincaidii* was present in both of our plots at Fir Butte, but not in the plots at the other sites. We identified nectar species (*Vicia* spp.) at Greenhill, Fir Butte, and Vinci. Our sampling period may have missed nectar species that have earlier phenologies. However, as we found only *Vicia* species, which provide relatively low quality nectar, we recommend efforts to increase both the diversity and cover of nectar species at these sites.

SUMMARY

The Recovery objectives from the Western Oregon and Southwestern Oregon Prairie Species Recovery Plan (USFWS 2010) specify that within habitat for *Lupinus sulphureus* ssp. *kincaidii*, *Erigeron decumbens* var. *decumbens*, and *Lomatium bradshawii*, there is to be ≥50% relative cover of non-woody natives at 70% of local populations, ≤15% cover of woody species, and no single non-native species with >50% cover. Furthermore, the monitoring indicators and corresponding thresholds for management actions from the Environmental Assessment (further outlined in the EA, Alternative D, pages 58-61) are:

Habitat indicator	Threshold for management
Woody vegetation	When canopy cover exceeds the level appropriate for the local habitat (5-10% for wet-prairie/vernal pool and upland prairie habitats)
Invasive species	When combined encroachment reaches 10%-35% or greater of the habitat block and/or a weed population covers >50% of a $1m^2$ area, depending on site conditions and species present.
Thatch	When the litter layer exceeds 10-20% cover and litter layer is detrimentally impacting native forb plant diversity or rare plant habitat.
Native Species	When there is a loss of 5%-10% of a site's existing cover and number of native plant species.

In our surveys, we found that the thresholds for management were exceeded for the following indicators:

Habitat indicator	Site	Indicator level
Woody vegetation	Greenhill 2	8% cover woody species
	Vinci 1	12% cover woody species
Invasive species	Fir Butte 1	121% introduced species cover
	Fir Butte 2	154% introduced species cover
	Greenhill 1	75% introduced species cover
	Greenhill 2	99% introduced species cover
	Oxbow West	29% introduced species cover
	Vinci 1	44% introduced species cover
	Vinci 2	39% introduced species cover
Thatch	Fir Butte 1	52% litter cover
	Fir Butte 2	81% litter cover
	Greenhill 1	89% litter cover
	Greenhill 2	91% litter cover
	Oxbow West	100% litter cover
	Vinci 1	94% litter cover
	Vinci 2	97% litter cover

The cover of invasive species and litter layer exceeded the threshold values for management at every site. The threshold for woody vegetation cover was exceeded at Greenhill 2 and Vinci 1. Although we did not document detrimental impacts on native forbs, it is likely that the litter is inhibiting their germination and establishment. For example, cover of *L. sulphureus* ssp. *kincaidii* was less than 2% at both Fir Butte sites (Appendix A), where litter cover was greater than 50%. Seedling recruitment may be further impeded by a moss layer, which was also high at these sites (Table 2). However, these ground cover layers may inhibit weed seed germination and establishment. Therefore, any management activities to remove litter should be followed by extensive weed control and seeding of native species. Finally, non-woody native species compose ≥50% relative cover only at one site, Greenhill 1.

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APPENDIX A. SPECIES FOUND IN SAMPLED PLOTS, 2010.

Abbreviations: N = native, I = introduced, F = forb, G = graminoid, S = shrub, T = tree.

Species	Native Status	Growth Habit	Family	% Cover (lower-upper 90% C.I.)						
				Fir Butte 1	Fir Butte 2	Greenhill 1	Greenhill 2	Oxbow	Vinci 1	Vinci 2
Achillea millefolium	N	F	Asteraceae	0	15.0 (11.1 - 19.6)	1.9 (0.7 - 4.3)	0.5 (0.03 - 2.3)	0	0	0
Agrostis exarata	I	G	Poaceae	0	0	0	0	0	0	0
Agrostis capillaris	I	G	Poaceae	82.2 (77.4 - 86.4)	76.2 (70.9 - 80.9)	0	4.0 (2.0 - 7.1)	0	1.5 (0.4 - 3.8)	1.4 (0.4 - 3.6)
Aira caryophyllea	I	G	Poaceae	0	0	0.5 (0.02 - 2.2)	1.5 (0.4 - 3.8)	0	0	0
Allium amplectens	N	F	Liliaceae	0	0	1.4 (0.4 - 3.6)	0.5 (0.03 - 2.3)	0	0	0
Alopecurus geniculatus	I	G	Poaceae	0	0	0	0	0.5 (0.02 - 2.2)	0	0
Alopecurus pratensis	I	G	Poaceae	0	0	0	0	0	0	0
Anthoxanthum odoratum	I	G	Poaceae	2.8 (1.2 - 5.5)	16.4 (12.3 - 21.1)	8.1 (5.2 - 11.8)	13.0 (9.3 - 17.6)	18.9 (14.6 - 23.8)	11.8 (8.3 - 16.2)	4.2 (2.2 - 7.2)
Arrhenatherum elatior	I	G	Poaceae	0.9 (0.2 - 2.9)	0.5 (.02 - 2.2)	0	10.0 (6.7 - 14.2)	0	0	0
Asteraceae sp.	N	F	Asteraceae	0	0	0	0	0.5 (0.02 - 2.2)	0	0.5 (0.02 - 2.2)
Beckmannia syzigachne	N	G	Poaceae	0	0	0	0.5 (0.03 - 2.3)	0	0	0
Briza minor	I	G	Poaceae	0	0	0	0	0.9 (0.2 - 2.9)	0	0
Brodiaea sp.	N	F	Liliaceae	0	0	0.5 (0.02 - 2.2)	0	0	0	0
Bromus hordeaceus	I	G	Poaceae	0	7.9 (5.1 - 11.7)	3.3 (1.6 - 6.1)	0.5 (0.03 - 2.3)	0	0	0.5 (0.02 - 2.2)

APPENDIX A (CONT.)

Abbreviations: N = native, I = introduced, F = forb, G = graminoid, S = shrub, T = tree.

Species	Native Status	Growth Habit	Family	% Cover (lower-upper 90% C.I.)						
				Fir Butte 1	Fir Butte 2	Greenhill 1	Greenhill 2	Oxbow	Vinci 1	Vinci 2
Danthonia californica	N	G	Poaceae	0	0	45.5 (39.7 - 51.4)	1.5 (0.4 - 3.8)	6.6 (4.0 - 10.1)	2.0 (0.7 - 4.5)	0.9 (0.2 - 2.9)
Daucus carota	I	F	Apiaceae	5.6 (3.3 - 8.9)	0.5 (0.02 - 2.2)	1.0 (0.2 - 3.0)	2.5 (1.0 - 5.2)	0	0	0
Deschampsia cespitosa	N	G	Poaceae	0	0	0.5 (0.02 - 2.2)	9.0 (5.9 - 13.0)	11.3 (7.9 - 15.6)	15.8 (11.7 - 20.6)	28.5 (23.4 - 34.0)
Dianthus armeria	I	F	Caryophyllaceae	0	0	0.5 (0.02 - 2.2)	0	0	0	0
Eleocharis acicularis	N	G	Cyperaceae	0	0	0.5 (0.02 - 2.2)	0	0	0	0
Epilobium ciliatum	N	F	Onagraceae	0	1.4 (0.4 - 3.6)	0	0.5 (0.03 - 2.3)	0	0	0
Eriophyllum lanatus	N	F	Asteraceae	0	0	6.2 (3.7 - 9.6)	0	0	0	0
Festuca arundinacea	I	G	Poaceae	0	2.3 (0.9 - 4.8)	8.5 (5.6 - 12.4)	26.5 (21.4 - 32.1)	0	0	0.9 (0.2 - 2.9)
Festuca roemeri	N	G	Poaceae	0	0	1.4 (0.4 - 3.6)	0	0	0	0
Fraxinus latifolia	N	T	Oleaceae	0	0	0.5 (0.02 - 2.2)	2.0 (0.7 - 4.5)	0	2.5 (1.0 - 5.1)	0
Fragaria virginia	N	F	Rosaceae	0	0	0.5 (0.02 - 2.2)	0	0	0	0
Galium aparine	I	F	Rubiaceae	5.6 (3.3 - 8.9)	0	0	0	0	0	0
Galium parisiense	I	F	Rubiaceae	0	0	0.5 (0.02 - 2.2)	0	0	0	0
Galium trifidum	N	F	Rubiaceae	29.4 (24.3 - 35.0)	0.9 (0.2 - 2.9)	0	0	0	2.0 (0.7 - 4.5)	0.5 (0.02 - 2.2)

APPENDIX A (CONT.)

Abbreviations: N = native, I = introduced, F = forb, G = graminoid, S = shrub, T = tree.

Species	Native Status	Growth Habit	Family	% Cover (lower-upper 90% C.I.)						
				Fir Butte 1	Fir Butte 2	Greenhill 1	Greenhill 2	Oxbow	Vinci 1	Vinci 2
Grindelia integrifolia	N	F	Asteraceae	0	0	0	1.0 (0.2 - 3.1)	8.5 (5.6 - 12.3)	3.4 (1.6 - 6.4)	2.8 (1.2 - 5.5)
Holcus lanatus	I	G	Poaceae	2.8 (1.2 - 5.5)	6.1 (3.6 - 9.5)	12.8 (9.2 - 17.2)	18.5 (14.1 - 23.6)	0.5 (0.02 - 2.2)	0	7.0 (4.4 - 10.6)
Hypericum perforatum	I	F	Clusiaceae	0	0.5 (0.02 - 2.2)	2.4 (0.9 - 4.9)	0	0	0	0.5 (0.02 - 2.2)
Hypochaeris radicata	I	F	Asteraceae	0	0	0.5 (0.02 - 2.2)	1.5 (0.4 - 3.8)	0	0	0.5 (0.02 - 2.2)
Juncus acuminatus	N	G	Juncaceae	0	0	0	0	0.9 (0.2 - 2.9)	0	0
Juncus articulatus	N	G	Juncaceae	0	0	3.3 (1.6 - 6.1)	0	0	1.0 (0.2 - 3.1)	1.4 (0.4 - 3.6)
Juncus bolanderi	N	G	Juncaceae	0	0	0	1.5 (0.4 - 3.8)	0	0	0
Juncus patens	N	G	Juncaceae	0	0	0	0	0	0.5 (0.03 - 2.3)	0
Juncus sp.	N	G	Juncaceae	0	0	0	0	0.5 (0.02 - 2.2)	0.5 (0.03 - 2.3)	0
Leontodon taraxacoides	I	F	Asteraceae	0	0	7.1 (4.4 - 10.7)	0.5 (0.03 - 2.3)	2.4 (0.9 - 4.9)	2.5 (1.0 - 5.1)	0.9 (0.2 - 2.9)
Leucanthemum vulgare	I	F	Asteraceae	0	0	0.5 (0.02 - 2.2)	2.0 (0.7 - 4.5)	2.8 (1.2 - 5.5)	7.9 (5.0 - 11.7)	7.9 (5.1 - 11.7)
Lotus micranthus	N	F	Fabaceae	0	0	0	0	0	1.0 (0.2 - 3.1)	2.8 (1.2 - 5.5)
Lotus sp.	N	F	Fabaceae	0	0	0.5 (0.02 - 2.2)	0	0	0	0
Lupinus sulphureus ssp. *kincaidii*	N	F	Fabaceae	1.4 (0.4 - 3.6)	0.9 (0.2 - 2.9)	0	0	0	0	0

APPENDIX A (CONT.)

Abbreviations: N = native, I = introduced, F = forb, G = graminoid, S = shrub, T = tree.

Species	Native Status	Growth Habit	Family	% Cover (lower-upper 90% C.I.)						
				Fir Butte 1	Fir Butte 2	Greenhill 1	Greenhill 2	Oxbow	Vinci 1	Vinci 2
Madia sp.	N	F	Asteraceae	0	0	0	0	0	2.0 (0.7 - 4.5)	0.9 (0.2 - 2.9)
Mentha pulegium	I	F	Lamiaceae	0	0	1.0 (0.2 - 3.0)	7.0 (4.3 - 10.7)	0	10.8 (7.5 - 15.1)	7.0 (4.4 - 10.6)
Microseris laciniata	N	F	Asteraceae	0	0	4.7 (2.6 - 7.9)	0	0	0.5 (0.03 - 2.3)	0
Myosotis discolor	I	F	Boraginaceae	0	0	1.0 (0.2 - 3.0)	1.0 (0.2 - 3.1)	0	0	0
Panicum capillare	N	G	Poaceae	0	0	0	0	12.3 (8.7 - 16.6)	1.0 (0.2 - 3.1)	0
Parentucellia viscosa	I	F	Scrophulariaceae	3.7 (1.9 - 6.6)	2.3 (0.9 - 4.8)	2.4 (0.9 - 4.9)	0.5 (0.03 - 2.3)	0	0.5 (0.03 - 2.3)	0.9 (0.2 - 2.9)
Perideridia gairdnerii	N	F	Apiaceae	0	0	2.4 (0.9 - 4.9)	0	0	0	0
Phalaris arundinacea	I	G	Poaceae	0	0	0	2.5 (1.0 - 5.2)	0	0	0
Plantago lanceolata	I	F	Plantaginaceae	6.1 (3.6 - 9.5)	0	3.8 (1.9 - 6.7)		1.9 (0.6 - 4.3)	0.5 (0.03 - 2.3)	0
Potentilla gracilis	N	F	Rosaceae	0	0	1.0 (0.2 - 3.0)	2.5 (1.0 - 5.2)	0	0	0
Prunella vulgaris ssp. *lanceolata*	N	F	Lamiaceae	0	0	5.2 (3.0 - 8.5)	3.5 (1.7 - 6.5)	2.4 (0.9 - 4.9)	1.5 (0.03 - 3.8)	0.9 (0.2 - 2.9)
Psilocarphus elatior	N	F	Asteraceae	0	0	0	0	0	0.5 (0.03 - 2.3)	0.5 (0.02 - 2.2)
Pteridium aquilinum	N	F	Dennstaedtiaceae	0	0.9 (0.2 - 2.9)	0	0	0	0	0
Quercus garryana	N	T	Fagaceae	0	0	0	0	0	0.5 (0.03 - 2.3)	0

APPENDIX A (CONT.)

Abbreviations: N = native, I = introduced, F = forb, G = graminoid, S = shrub, T = tree.

Species	Native Status	Growth Habit	Family	% Cover (lower-upper 90% C.I.)						
				Fir Butte 1	Fir Butte 2	Greenhill 1	Greenhill 2	Oxbow	Vinci 1	Vinci 2
Rubus armeniacus	I	S	Rosaceae	0.5 (0.02 - 2.2)	0.5 (0.02 - 2.2)	0.5 (0.02 - 2.2)	1.0 (0.2 - 3.1)	0.5 (0.02 - 2.2)	4.9 (2.7 - 8.2)	2.8 (1.2 - 5.5)
Rubus laciniatus	I	S	Rosaceae	0	0	0	0	0	1.0 (0.2 - 3.1)	0
Rumex acetosella	I	F	Polygonaceae	2.3 (0.9 - 4.8)	0.5 (0.02 - 2.2)	0	0	0.5 (0.02 - 2.2)	0	0
Rumex crispus	I	F	Polygonaceae	0	0	0	0.5 (0.03 - 2.3)	0	0	0
Senecio jacobaea	I	F	Asteraceae	0.5 (0.02 - 2.2)	0	0	0	0	0.5 (0.03 - 2.3)	0
Symphyotrichum hallii	N	F	Asteraceae	0	0	1.0 (0.2 - 3.0)	1.0 (0.2 - 3.1)	4.2 (2.2 - 7.3)	5.9 (3.4 - 9.4)	0.9 (0.2 - 2.9)
Toxicodendron diversilobum	N	S	Anacardiaceae	0	0	0.5 (0.02 - 2.2)	1.0 (0.2 - 3.1)	0	0	0
Veronica scutellata	N	F	Scrophulariaceae	0	0	2.8 (1.2 - 5.5)	0	0	0	0
Vicia cracca	I	F	Fabaceae	0	0	0.5 (0.02 - 2.2)	0	0	0	0
Vicia hirsuta	I	F	Fabaceae	1.9 (0.6 - 4.2)	4.2 (2.2 - 7.2)	11.4 (8.0 - 15.6)	0	0	0.5 (0.03 - 2.3)	0
Vicia sativa	I	F	Fabaceae	4.2 (2.2 - 7.2)	29.4 (24.3 - 40.0)	0	0	0	0	0
Vicia tetrasperma	I	F	Fabaceae	0	0.5 (0.02 - 2.2)	1.0 (0.2 - 3.0)	3.5 (1.7 - 6.5)	0	0	0
Vicia sp.	I	F	Fabaceae	0	0.5 (0.02 - 2.2)	0	0	0	0	0
Vulpia bromoides	I	G	Poaceae	0	0	0.5 (0.02 - 2.2)	0	0	0	0
Wyethia angustifolia	N	F	Asteraceae	0	0	2.8 (1.2 - 5.5)	2.5 (1.0 - 5.2)	0	0	0