

Habitat restoration and monitoring for Kincaid's Lupine (*Lupinus oreganus*) at Fir Butte: 2018 annual report



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Report for the Bureau of Land Management, Northwest Oregon District, Agreement # L14AC00314 and L18AC00055

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Institute for Applied Ecology



PREFACE

IAE is a non-profit organization whose mission is conservation of native ecosystems through restoration, research and education. IAE provides services to public and private agencies and individuals through development and communication of information on ecosystems, species, and effective management strategies. Restoration of habitats, with a concentration on rare and invasive species, is a primary focus. IAE conducts its work through partnerships with a diverse group of agencies, organizations and the private sector. IAE aims to link its community with native habitats through education and outreach.



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Cover photograph: Looking north at a Kincaid's lupine patch in June 2018. Photo by Andrew Esterson.

SUGGESTED CITATION

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Habitat restoration and monitoring for Kincaid's lupine (*Lupinus oreganus*) at Fir Butte: 2018 annual report

1. EXECUTIVE SUMMARY

This report documents habitat restoration and monitoring work conducted in 2018 by the Institute for Applied Ecology (IAE) at Fir Butte, an 18-acre site located in Eugene, Oregon that is owned and managed by the Bureau of Land Management, Northwest Oregon District (BLM). Fir Butte hosts a large population of the federally endangered Fender's blue butterfly (*Icaricia icarioides fenderi*) and its host plant, the federally threatened Kincaid's lupine (*Lupinus oreganus*), along with other Bureau sensitive species.

To conserve and bolster populations of critical species at Fir Butte, the BLM has partnered with IAE since 2012 and has been actively performing habitat restoration actions at the site since the onset of the partnership. In 2018, IAE helped plan and implement a variety of activities to support restoration and conservation efforts. Activities included weed control, nectar island creation, native species planting, monitoring Fender's blue butterflies, surveying the plant community, supporting prescribed burns and an ongoing experiment evaluating the non-target impacts of a grass-specific herbicide on prairies supporting Fender's blue butterflies.

Results from 2018 monitoring indicate that:

- Kincaid's lupine foliar cover decreased from 2017 to 2018 from 4,834 m² to 3,352m², respectively;
- Himalayan blackberry cover has decreased since the initiation of monitoring at this site, but at greater than nine percent, cover still remains above the threshold allowed in the Recovery Plan for the Prairie Species of Western Oregon and Southwestern Washington (Recovery Plan, USFWS 2010);
- Introduced perennial grasses were the dominant components of the plant community;
- Dominant native forbs at the site are Kincaid's lupine and bracken fern (*Pteridium aquilinum*). Percent cover of other native forbs at the site are below 2%;
- From 2011 to 2018, relative cover of introduced species in Kincaid's lupine habitat has ranged from 80-90%, far exceeding the 50% threshold set as part of the Recovery Plan. In 2018, relative cover of introduced species was 83%.

- High litter cover observed in recent years could limit native species establishment. There is little bare ground available for seed germination.

2. INTRODUCTION

2.1. Site background

Fir Butte is an 18-acre site owned and managed by the Bureau of Land Management, Northwest Oregon District (BLM) and located in Lane County, Oregon, in the West Eugene Wetlands (WEW). Fir Butte is part of a network of sites in the Eugene West Recovery Zone within the Willamette Valley that supports a large population of the federally endangered Fender's blue butterfly (*Icaricia icarioides fenderi*) and the federally threatened Kincaid's lupine (*Lupinus oreganus*; Figure 1). Bureau-Sensitive species including white topped aster (*Sericocarpus rigidus*), and three rare bryophyte species have been observed at Fir Butte as well. Populations of listed species at Fir Butte are critical for meeting U.S. Fish and Wildlife Service (USFWS) delisting goals referenced in the 2010 Recovery Plan for the Prairie Species of Western Oregon and Southwestern Washington (Recovery Plan, USFWS 2010).

Prior to purchase by the BLM, Fir Butte was used as a horse pasture and hay field. The site includes both upland and wetland prairie habitats. The overall habitat quality at the site is poor, with heavy infestations of introduced plants such as Himalayan blackberry (*Rubus armeniacus*) and tall oatgrass (*Arrhenatherum elatius*).

The BLM began partnering with the Institute for Applied Ecology (IAE) in the early 2000s to monitor the Kincaid's lupine population and in 2012 to perform habitat restoration actions at the site. Since restoration actions were initiated, the Fender's blue butterfly population has remained stable, and with the exception of a decline in 2018, the Kincaid's lupine population has steadily increased. In general, habitat restoration work conducted by IAE has improved habitat conditions at Fir Butte, and while the site does not yet meet the habitat quality and listed species population size and trend benchmarks identified in the Recovery Plan, conditions at this site are moving in the right direction to meet benchmark recovery goals.



FIGURE 1. KINCAID'S LUPINE (*LUPINUS OREGANUS*).

2.2. Species background

Kincaid's lupine (Figure 1), a rare member of the legume family (Fabaceae), is listed by the Oregon Department of Agriculture (ODA) and the USFWS as a threatened species. Kincaid's lupine is found in remnant prairies in the Willamette Valley, southwestern Washington, and forest openings in Douglas County, Oregon. In the Willamette Valley, Kincaid's lupine serves as a larval host plant for the federally endangered Fender's blue butterfly, making conservation of Kincaid's lupine a common strategy for the success of both species.



FIGURE 2. HERBIVORY OF KINCAID'S LUPINE BY FENDER'S BLUE BUTTERFLY LARVAE RESULTS IN CLUSTERS OF DAMAGED STEMS, LEAVES, AND GROWING POINTS (LEFT) BECAUSE THE LARVAE (RIGHT) TYPICALLY FEED ON YOUNG LEAVES AND APICAL MERISTEMS.

Kincaid's lupine is an herbaceous perennial that reproduces by seed. Plants form clumps of basal leaves and eventually produce one or more flowering stems. This species also spreads vegetatively, though it is unknown to what extent vegetative growth might result in the formation of physiologically distinct clones. Kincaid's lupine requires insects for successful fertilization and seed formation (Kaye 1999).

Fender's blue butterfly oviposits small white eggs on the undersides of Kincaid's lupine leaves in late spring. After eggs hatch, the larvae emerge and feed on Kincaid's lupine leaves (Figure 2) before overwintering in the soil near the base of plants.

3. GOALS AND OBJECTIVES

The goals of this project are to improve habitat quality such that the Kincaid's lupine and Fender's blue butterfly populations contribute to USFWS delisting goals, decrease the abundance of non-native species, and increase the abundance and diversity of native plant species.

Specific project objectives for restoration and maintenance of this sensitive habitat include:

- Maintain or increase the area of Kincaid's lupine foliar cover;
- Reduce blackberry to below 5% absolute cover;
- Remove all meadow knapweed (*Centaurea pratensis*) and Scotch broom (*Cytisus scoparius*); and
- Increase native species relative cover to 50% or greater.

In addition, this report summarizes the results of monitoring Kincaid's lupine and the plant community at Fir Butte in 2018 in order to assess the effects of management treatments that have occurred and are planned to occur. Monitoring goals include:

- Summarize the abundance of Kincaid's lupine in 2018 and long term population trends;
- Summarize the plant community composition in order to assess if management thresholds for de- or down-listing are being met; and
- Obtain pre-treatment data prior to planned prescribed fire and herbicide treatments scheduled for the fall of 2018 and 2019.

4. RESTORATION ACTIVITIES

4.1. Overview

In 2018, IAE helped plan and implement a variety of activities to support restoration and conservation efforts at Fir Butte. Activities included weed control (via mowing, grubbing and herbicide application), nectar island creation, native species planting, monitoring Fender's blue butterflies, surveying the plant community, supporting a prescribed burn and an ongoing experiment evaluating the non-target impacts of a grass specific herbicide on prairies supporting Fender's blue butterflies. Fender's blue butterfly data collection methodology and data are not reported here, but are submitted to the BLM in a separate document. Kincaid's lupine and vegetation community monitoring data are reported below in Section 5. Table 1 summarizes the restoration actions completed at Fir Butte in 2018. See Appendix 1 for a summary of all management actions completed through this project from 2008 to the present.

TABLE 1. MANAGEMENT ACTIONS COMPLETED AT FIR BUTTE IN 2018.

Date	Action	Personnel*	Description
3/20	Herbicide application	Habitat Restoration LLC.	Applied Fusilade herbicide to four experimental plots to test non-target impacts of using Fusilade to manage prairie harboring Fender's blue butterfly
4/18	Weed control	IAE	Flame weeded meadow knapweed in NW corner
4/18	Weed control	IAE/BLM/LGYC	Picked bracken fern on south east side
5/8	Weed control	LGYC	Picked bracken fern on south east side
5/17	Site preparation	IAE/BLM	Flame weeded a 9mx8m plot for nectar island establishment and covered plot with plastic for solarization treatment
5/21	Weed control	IAE	Mowed bracken fern
5/29	Weed control	IAE/BLM	Mowed tall oatgrass with string trimmer
5/30	Weed control	IAE	Mowed tall oatgrass with string trimmer

Date	Action	Personnel*	Description
6/1	Weed control/site preparation	IAE	Mowed tall oatgrass with string trimmer and put plastic on nectar island
6/5	Weed control	IAE	Mowed tall oatgrass with string trimmer
6/8	Weed control	IAE	Mowed tall oatgrass with string trimmer
6/8	Site preparation	IAE	Established a new 6mX20m nectar island by clearing off vegetation with a string trimmer
6/9	Site preparation	IAE	Covered mowed nectar island with plastic for solarization treatment
6/13	Weed control	IAE	Mowed meadow knapweed in northwest corner
6/26	Weed control	IAE	Pulled knapweed
7/10	Weed control	IAE	Pulled knapweed
7/26	Weed control	IAE	Pulled knapweed
8/14	Site preparation	IAE	Flagged nectar islands
8/27	Weed control	Contractor	Site wide mowing (except for burn unit and nectar islands)
9/6	Site preparation	IAE/BLM	Removed plastic from solarization treatments
10/2	Weed control	IAE/BLM/LGYC	Removed Scotch broom from SE corner
10/13	Prescribed burn	Interagency team	Burned approximately 5 acres in SE corner and all nectar islands
10/17	Seeding	IAE	Broadcast nectar island seed mix over nectar islands
12/7	Herbicide application	IAE/Contractor	Glyphosate was broadcast over 3 acres in the SE corner (burn unit); Glyphosate was spot sprayed to target meadow knapweed site wide

*Institute for Applied Ecology (IAE); Bureau of Land Management (BLM); Looking Glass Youth Crew (LGYC)

4.2. Nectar islands

Nectar islands were first created at Fir Butte in 2014 (Figure 3). The primary objective was to establish small 'islands' of nectar resources for pollinators, especially Fender's blue butterfly. Established nectar islands will also serve as source sites for distributing native seed to the surrounding prairie, helping to

increase the diversity and abundance of native species. Nectar islands were first established by covering five 8x10m blocks with weed barrier for a year. After one year the weed barrier was removed and blocks were seeded and/or plugs were planted with native species. Unfortunately, since their creation the nectar islands have been invaded by non-native grasses. In 2017, in order to reduce non-native grass cover in the newly established seed islands, the weed barrier fabric was left in place and plugs, bulbs and a seed mix were directly added into holes cut in the fabric (Esterson 2018). In 2018 many of the holes were filled with native species (Figure 4).

In June 2018, IAE and BLM staff agreed to develop three additional nectar islands via solarization and herbicide treatment. One 9x8m plot (Plot 4e) was flame weeded and one 6x20m plot (Plot 7e) was mowed with a string trimmer; both techniques were used to reduce thatch prior to solarization. After the thatch reduction treatment was implemented, plastic was secured on top of each plot for a three-month solarization treatment. On September 6th plastic was removed from each plot (Figure 5). On October 17th a nectar seed mix was broadcast on each plot (Table 2); seed was provided by the City of Eugene. On December 7, a contractor applied glyphosate over an additional 20x13m plot (Plot 4e) to begin the chemical fallow process of creating a nectar island.

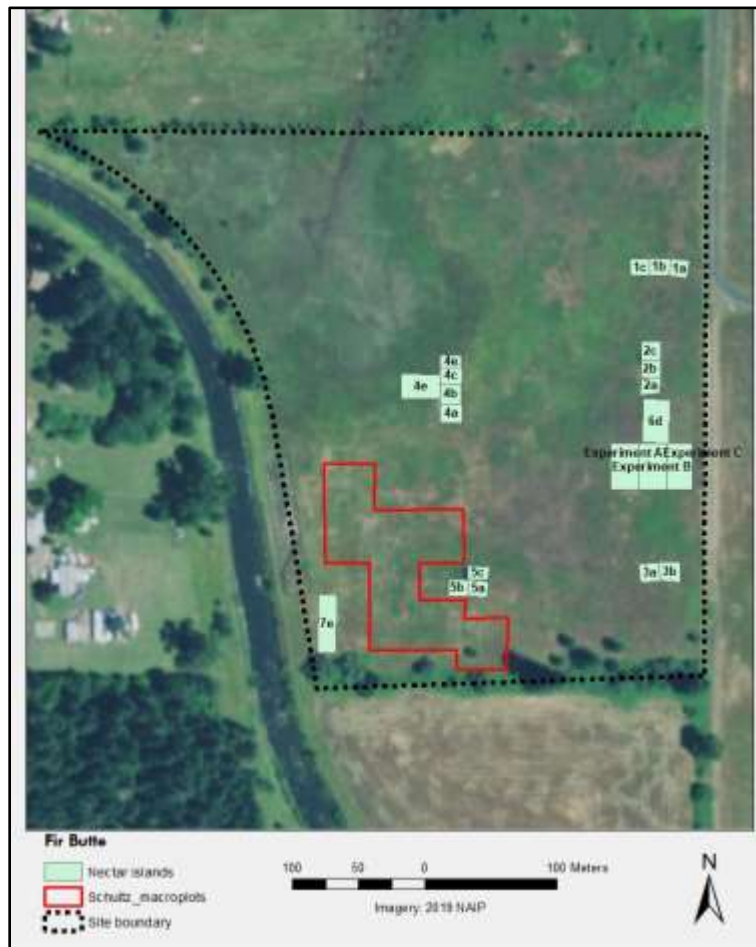


FIGURE 3. NECTAR ISLANDS AND EXPERIMENTAL PLOT LOCATIONS AT FIR BUTTE. PLOTS WITH AN 'A' WERE ESTABLISHED IN 2014, 'B' IN 2015, 'C' IN 2016, 'D' IN 2017 AND 'E' IN 2018.



FIGURE 4. LOOKING SOUTH ACROSS A NECTAR ISLAND ON JUNE 12, 2018. PLUGS OF NATIVE SPECIES WERE PLANTED IN THE FALL OF 2017. OREGON SUNSHINE, SHORTSPUR SEABLUSH, GLOBE GILIA, CHECKERMALLOW, AND FAREWELL-TO-SPRING CAN BE SEEN IN THE FOREGROUND.



FIGURE 5. NECTAR ISLAND IN JUNE 2018 WITH PLASTIC COVERING FOR SOLARIZATION (LEFT). NECTAR ISLAND IN SEPTEMBER 2018 AFTER SOLARIZATION WAS COMPLETED (RIGHT).

TABLE 2. 2018 FIR BUTTE NECTAR ISLAND SEED MIX.

Species	Common name	Pounds/Acre
<i>Achillea millefolium</i>	common yarrow	0.1
<i>Allium amplexans</i>	narrowleaf onion	1.2
<i>Camassia leichtlinii</i>	Suksdorf's large camas	5.01
<i>Eriophyllum lanatum</i>	wooly sunflower	0.81
<i>Lomatium nudicaule</i>	barestem biscuitroot	1.21
<i>Luzula comosa</i>	Pacific woodrush	0.12
<i>Microseris laciniata</i>	cutleaf silverpuffs	0.29
<i>Plectritis congesta</i>	shortspur seablush	0.2
<i>Prunella vulgaris</i>	self-heal	0.34
<i>Ranunculus occidentalis</i>	Western buttercup	0.44
<i>Sidalcea malviflora</i> ssp. <i>virgata</i>	rose checkermallow	4
<i>Sisyrinchium idahoense</i>	Idaho blue-eyed grass	0.22

4.3 Species control

In 2018, non-native species management primarily targeted tall oatgrass, bracken fern, oxeye daisy (*Leucanthemum vulgare*) and meadow knapweed (*Centaurea pratensis*). IAE and BLM staff used string trimmers to mow tall oatgrass, the Looking Glass youth crew pulled bracken fern fronds, IAE staff cut bracken fern and oxeye daisy with a string trimmer and meadow knapweed was pulled multiple times by IAE and BLM staff throughout the growing season. In addition, in December, all meadow knapweed was flagged and IAE staff applied a 1.5% glyphosate solution (2 oz/gallon AquaStar; 9.4oz/gallon Nu-Film IR; and 0.3oz/gallon Hi Lite) using a backpack sprayer to all flagged meadow knapweed.

4.3.1. Tall oatgrass

Tall oatgrass has been regularly mowed with a string trimmer in late May to early June dating back to at least 2013 (Appendix 1). The goal of mowing is to increase access by Fender's blue butterfly and other pollinators to patches of Kincaid's lupine; additionally, this treatment may decrease the vigor of the introduced perennial grasses and decrease the spread of seed. Based on 2010 and 2018 vegetation maps it does not appear that this method is effective at tall oatgrass control, as the population has expanded, mostly in the northeast corner which has a dense population of Kincaid's lupine (Figure 6, Figure 7). In addition, the amount of staff time needed to mow tall oatgrass has nearly doubled; in 2018 it took approximately 40 hours to mow the tall oatgrass using string trimmers, whereas in previous years it took approximately 24 hours. Alternative methods should be looked at for future tall oatgrass control.

One method to expedite tall oatgrass mowing is to use a brush cutter or a tractor mounted with a mower in areas where Kincaid's lupine is not present. A two-meter buffer should be maintained around all Kincaid's lupine patches to avoid negative impacts to this species (USFWS 2014). Maintaining the

required buffer may prove to be difficult as Kincaid's lupine habitat overlaps with much of the tall oatgrass; however, mechanical mowing wherever possible may save time since less area will need to be hand-mowed with a string trimmer. An alternative approach is to wipe tall oatgrass with glyphosate once it is taller than Kincaid's lupine. This may be a feasible alternative in 2019 since herbicide use is now permitted.

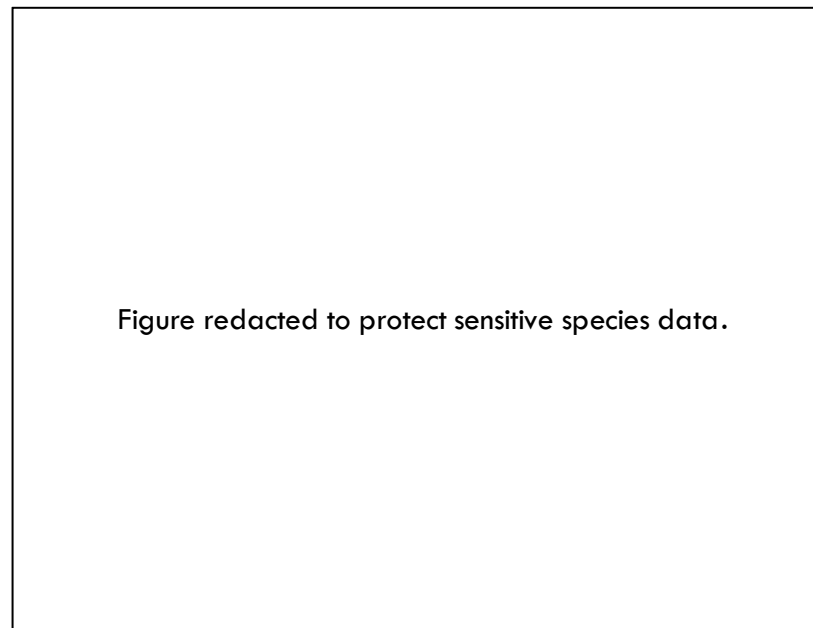


FIGURE 6. TALL OAT GRASS DISTRIBUTION (ORANGE) AT FIR BUTTE IN 2010 (TOP) AND 2018 (BOTTOM).



FIGURE 7. TALL OATGRASS GROWING IN A KINCAID'S LUPINE PATCH (LEFT). KINCAID'S LUPINE PATCH AFTER TALL OATGRASS WAS MOWED (RIGHT)

4.3.2. Bracken fern

In 2018 bracken fern fronds were cut multiple times in April and May by the Looking Glass Youth Crew (Figure 8) and between May and July by IAE staff using string trimmers. Unfortunately, these efforts were not able to keep pace with bracken fern frond production as new fronds continued to grow through the summer, and this species continues to expand into Kincaid's lupine habitat. The Biological Opinion (USFWS 2014) prohibits mowing Kincaid's lupine-occupied areas with a tractor during the



FIGURE 8. LOOKING GLASS YOUTH CREW REMOVING BRACKEN FERN FRONDS ON APRIL 17, 2018.

Kincaid's lupine growing season, which limits the ability to control bracken fern. Continued efforts pulling bracken fern may reduce its vigor and perhaps slow range expansion. Previous work by Milligan et al. (2016) has shown that control of bracken fern required six to eight years of repeated treatments in order to decrease cover of this species. In this study, a single treatment of herbicide at the beginning of the study, followed by cutting of emerging fronds two to three times/year over an eight-year period, was necessary to reduce cover of the species. Cutting alone was equally effective as the one-time herbicide treatment followed by cutting. Annual spot spray treatments over the same eight-year period were also effective. Management of this species requires a committed effort to deplete the carbohydrate resources of this rhizomatous species.

4.3.3. Oxeye daisy

Oxeye daisy is primarily located on the western edge of Fir Butte and is only found in a few dense patches. Flowers were removed with a string trimmer in June and July to prevent seed from spreading. If left uncontrolled, oxeye daisy may expand rapidly throughout Fir Butte (Clements et al. 2004). The best control method to reduce the oxeye daisy population is with herbicide application.

4.3.4. Meadow knapweed

Meadow knapweed is becoming increasingly more abundant at Fir Butte. The majority of meadow knapweed is found on the perimeter of the site on the north, east and south sides, with the north and east edges containing the densest patches. Individual plants were also found scattered throughout the site. To reduce seed set, meadow knapweed stems were cut, bagged and removed from the site multiple times during the growing season. In December, meadow knapweed individuals were sprayed with a 1.5% glyphosate solution (Figure 9).

One of the challenges controlling meadow knapweed at Fir Butte is the primary seed source population is on private property to the north and east of BLM-owned land. The land owner to the north was contacted this year by IAE staff and showed interest in allowing a third party to manage the meadow knapweed. The USFWS will follow up with the land owner and work to arrange for meadow knapweed treatment in 2019. The land owner to the east was also contacted but declined help managing meadow knapweed on their property.

Control of seedset of this species is crucial to stopping the spread of this weed. Dennehy et al. (2011) recommends manual removal only when herbicides are not available, and emphasizes the need to remove all roots. Grubbing can be successful if the entire root system is removed, however this process can also result in substantial ground disturbance. Cutting or mowing stems to remove flowers reduces seed set but does not kill the plant, and it is often necessary to implement this treatment multiple times throughout a growing season. Mowing before plants reach maturity can reduce plant vigor; however, mowed plants still produce flowers that are low to the ground and are often missed when flowering stem removal occurs. Herbicide application can be a successful method if the application is at the correct time (rosette stage either in spring or fall) (Dennehy et al. 2011). An integrated approach will be needed to control meadow knapweed for the foreseeable future.



FIGURE 9. MEADOW KNAPWEED IN THE SOUTHERN PORTION OF FIR BUTTE BEFORE HERBICIDE APPLICATION ON DECEMBER 7TH, 2018 (TOP). MEADOW KNAPWEED ON JANUARY 8TH, 2019 (BOTTOM) AFTER HERBICIDE TREATMENT WAS BEGINNING TO EFFECT PLANTS.

4.4. Prescribed burn

A prescribed burn was executed on October 13th, 2018. Approximately five acres in the SE corner and all nectar islands except the more recently installed 2017 and 2018 islands in the SW corner were burned (Figure 10 and Figure 11).

Prescribed burns have been an important component to habitat management at Fir Butte. Portions of the site burned in 2008, 2009, 2012, 2014, 2016 and 2017. All burns have been in compliance with guidelines described in the Biological Opinion (USFWS 2014; standards 9 and 36). Standard 36 requires that no more than 1/3 of Fender's blue butterfly habitat is burned in a given year if more than 100 Fender's blue butterflies occupy the site; therefore, burn units are typically less than five acres unless they contain unsuitable habitat for Fender's blue butterfly (e.g. wet prairie). Burn units are rotated annually and not burned again for at least three years.



FIGURE 10. 2018 BURN UNIT LOCATION AT FIR BUTTE IN 2018 (CROSS-HATCHED AREAS). UNITS WERE BURNED ON 10/13/18.



FIGURE 11. 2018 PRESCRIBED BURN AT FIR BUTTE WAS EXECUTED ON OCTOBER 13. APPROXIMATELY FIVE ACRES OF THE SE CORNER (LEFT) AND NECTAR ISLANDS (RIGHT) WERE BURNED.

4.5. Grass-specific herbicide experiment

An on-going experiment evaluating long-term effects of annual application of grass-specific herbicide on invasive grasses, Fender's blue butterfly and its habitat continued in 2018. IAE contracted Habitat Restoration, LLC. to apply herbicide on experimental plots. Specifically, Fusilade DX (20 oz./acre) and Nu-Film (6oz/acre) were applied to four 20m x 20m plots using a boom-sprayer mounted on an ATV on March 20th (Figure 12). Experimental plots were mowed in September. These plots are not monitored by IAE, as they are part of a long-term experiment established by Dr. Cheryl Schultz from Washington State University.



FIGURE 12. FUSILADE APPLICATION ON EXPERIMENTAL PLOTS AT FIR BUTTE. THE APPLICATION WAS PERFORMED BY HABITAT RESTORATION LLC. ON MARCH 20TH, 2019.

4.6. Chemical fallow treatment

Once the prescribed burn was completed in 2018 and herbicide use was permitted, BLM and IAE staff agreed to begin a chemical fallow process in the prescribed burn unit. Since Kincaid's lupine is present in the unit, broadcast chemical applications can only occur between September and February. Therefore, once vegetation began greening up after the prescribed burn a contractor applied a broadcast glyphosate application using a boom-sprayer mounted on an ATV on December 7. The primary species targeted were non-native grasses. Follow-up spot spraying with glyphosate will occur in this unit in 2019.

5. MONITORING AND HABITAT ASSESSMENT

Monitoring Kincaid's lupine was initiated at Fir Butte in 1998 to provide data on population trends and test the effects of experimental habitat management treatments implemented from 2003-2006 on

Kincaid's lupine cover and Fender's blue butterfly reproductive success. That study has since concluded; however, the existing infrastructure continues to be utilized for monitoring the Kincaid's lupine population. The Fir Butte plant community has been monitored using a variety of methods over time to assess the presence and quantity of certain weedy species, and the overall habitat quality of the site. Habitat assessment activities are summarized in Table 3.

5.1. Monitoring and habitat assessment methods

5.1.1. Kincaid's lupine monitoring methods

5.1.1.1. ORIGINAL PLOT DESIGN

In 1998, a 216m x 288m macroplot covering the entire area occupied by Kincaid's lupine at Fir Butte was established. This macroplot was further divided into 18 subplots, each 24m x 108m with the long axis running west to east (Figure 13). Within each of the 18 subplots are two nested 100m transects (n=36) surrounded by a two-meter wide buffer on each of the long sides and a 4 m wide buffer on each of the narrow sides. Transects are marked on both ends with concrete markers. Corners of the macroplots are marked with t-posts or concrete markers. Each fence post or marker is labeled with a pre-numbered aluminum tag. Additional information regarding on initial plot establishment can be found in Thorpe (2011).

While the initial study has been completed (Thorpe 2011), these permanent transects continue to be utilized to sample the Kincaid's lupine population and plant community at this site. From 1998-2010, both the north and south sides of each transect were monitored for Kincaid's lupine cover and target weedy species; since 2011, only the north side of the tape was monitored.

5.1.1.2. 2018 MONITORING METHOD

In 2018, we recorded the foliar cover of Kincaid's lupine, number of mature and aborted Kincaid's lupine inflorescences in each 100m transects. Foliar cover of Kincaid's lupine was determined by measuring the approximate rectangular area occupied by a clump of plants in centimeters. Population estimates for Kincaid's lupine are made by averaging the data across all monitored transects and multiplying by the total number of possible 100m transects at the site (n=460). Each 100m transect is divided into 5m sections. The foliar cover and count of mature and aborted racemes are recorded in each 5m section.

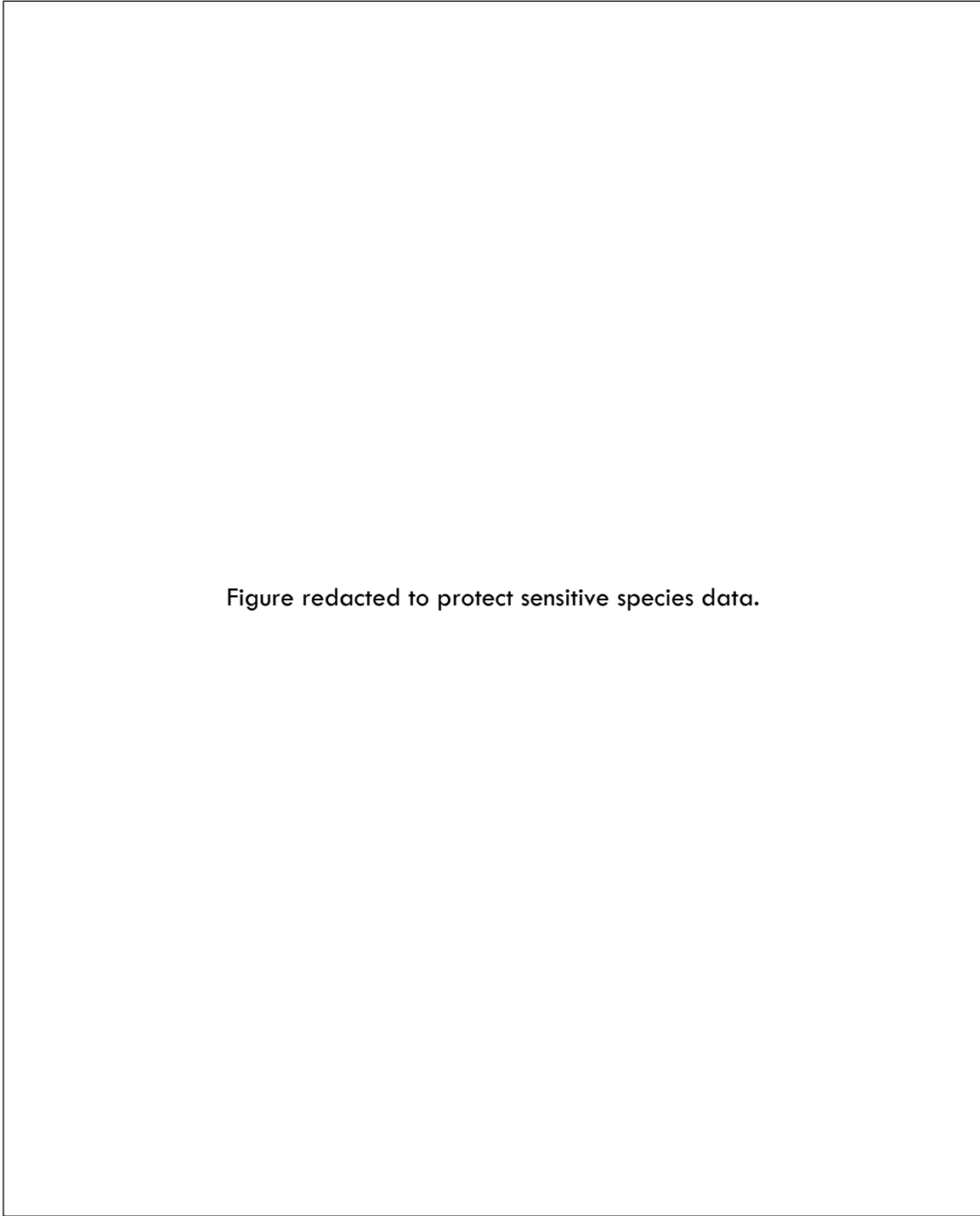


FIGURE 13. DIAGRAM OF PLOT LAYOUT FOR KINCAID'S LUPINE MONITORING AT FIR BUTTE. THE ENTIRE OCCUPIED PORTION OF THE SITE IS DIVIDED IN 18 SUBPLOTS. TWO 100M TRANSECTS ARE MONITORED IN EACH OF THE SUBPLOTS IN 5M SECTIONS.

5.1.2. Vegetation community monitoring methods

Since IAE implemented monitoring to quantify vegetation cover at Fir Butte in 2007, IAE field crews have performed four levels of community monitoring; point intercept, percent cover of target weedy species, percent cover to species level and Relevé plots of nectar islands. Data collected using the point intercept method are summarized in Gray and Bahm (2015). Table 3 outlines the years in which each of the other three monitoring methods were used at Fir Butte. Vegetation community monitoring activities are guided by planned management actions, the need to address habitat quality standards as described in the Recovery Plan, management thresholds set forth by BLM and funding availability. In 2017 and 2018 habitat monitoring focused on assessment of areas to be treated with herbicide, and evaluating the cover (and presence) of target weedy species.

TABLE 3. COMMUNITY MONITORING SCHEDULE FOR FIR BUTTE FROM 2007-2018.

Monitoring type	Macroplot	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
% cover (all species)	In Kincaid's lupine macroplot					X			X	X		X	X*
Relevé	Proposed burn units/nectar islands												X
% cover (target weedy species)	In Kincaid's lupine macroplot	X	X	X	X	X			X	X		X	X

*In 2018, the percent cover of all species was only measured in the proposed burn unit (approximately equivalent to sub-plots 1-5) rather than across the entire lupine macroplot.

5.1.2.1. PERCENT COVER OF TARGET WEEDY SPECIES

In conjunction with Kincaid's lupine monitoring, percent cover of Himalayan blackberry and bracken fern and the presence/absence of meadow knapweed were recorded in the same 5m sections used to monitor the Kincaid's lupine. Cover of tall oatgrass was measured in each of the 5m sections beginning in 2011. In 2018, cover of hedge bindweed (*Calystegia sepium*) was quantified in each sub-plot. Confidence intervals for these values are calculated by considering the average cover of each of these species in each of the transects. These measurements allow us to quantify changes in cover of these target weedy species and assess the effects of management treatments at the site in conjunction with changes in Kincaid's lupine cover.

5.1.2.2. PERCENT COVER BY SPECIES

In late June 2018, 29 randomly placed 1m² plots were monitored within the southeast portion of the site (roughly equivalent to Kincaid's lupine subplots 1-4; Figure 13). We assessed the percent cover of all vascular plant species and four ground cover types (bare soil, litter, rock, and moss). Percent cover was visually estimated to the nearest 1%; for species occurring at <1% cover we estimated cover to 0.1% or 0.5%. Species names and supplementary information follows the USDA Plants Database (<http://plants.usda.gov/java/>) and local floras.

Relevé plots

In 2018, in order to quickly assess the status of the plant community in areas within Fir Butte that were scheduled to be burned in the fall of 2018, five areas (A-E) were monitored using the Relevé method. The Relevé method assigns cover classes and sociability classes as described in Table 4 (Mueller-Dombois and Ellenberg 2002). Within each unit (A-E), one or two 8m x 10m plots (with the shorter dimension running N/S) were assessed by visually estimating the cover and sociability classes to each species found within the plot. Follow-up monitoring will take place to determine changes to the plant community and efficacy of management actions in 2020. Pre-treatment data are reported in Appendix 5.

TABLE 4. COVER AND SOCIABILITY CLASSES USED FOR RELEVÉ PLOTS AT FIR BUTTE IN 2018. TABLE MODIFIED FROM MUELLER-DOMBOIS AND ELLENBERG 2002.

Cover class	Cover class range (%)		Sociability class	Sociability class criteria
5	75-100%		1	Occurring in large nearly pure stands
4	50-74.9%		2	Occurring in large aggregates, coppices or in carpets
3	25-49.9%		3	Occurring in small aggregates, clusters or cushions
2	5-24.9%		4	Occurring in clumps or bunches
1	1-4.9%		5	Occurring singly
+	0.5-0.9%			
r	Observed, rare			

5.2. Monitoring and site assessment results

5.2.1. Kincaid's lupine

Between 2017 and 2018, Kincaid's lupine cover and racemes decreased. Kincaid's lupine cover decreased by 30%, from 4,834 m² (± 982 m²) to 3,352m² (± 703 m²) (Figure 14 and Table 5). The estimated number of mature racemes decreased by more than 50% (from ~247,000 to ~113,000) (Figure 14, Appendix 4).

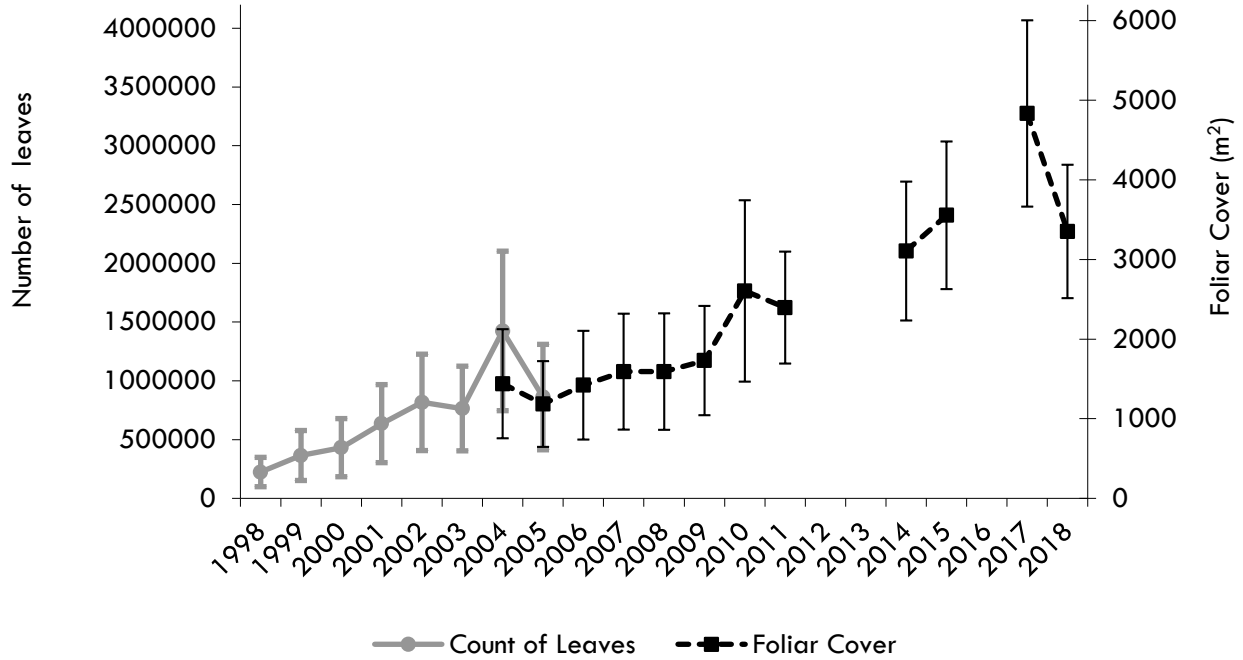


FIGURE 14. COVER OF KINCAID'S LUPINE AT FIR BUTTE FROM 1998 TO PRESENT. ERROR BARS REPRESENT 95% CONFIDENCE INTERVALS. DATA WAS NOT RECORDED IN 2012, 2013 NOR 2016.

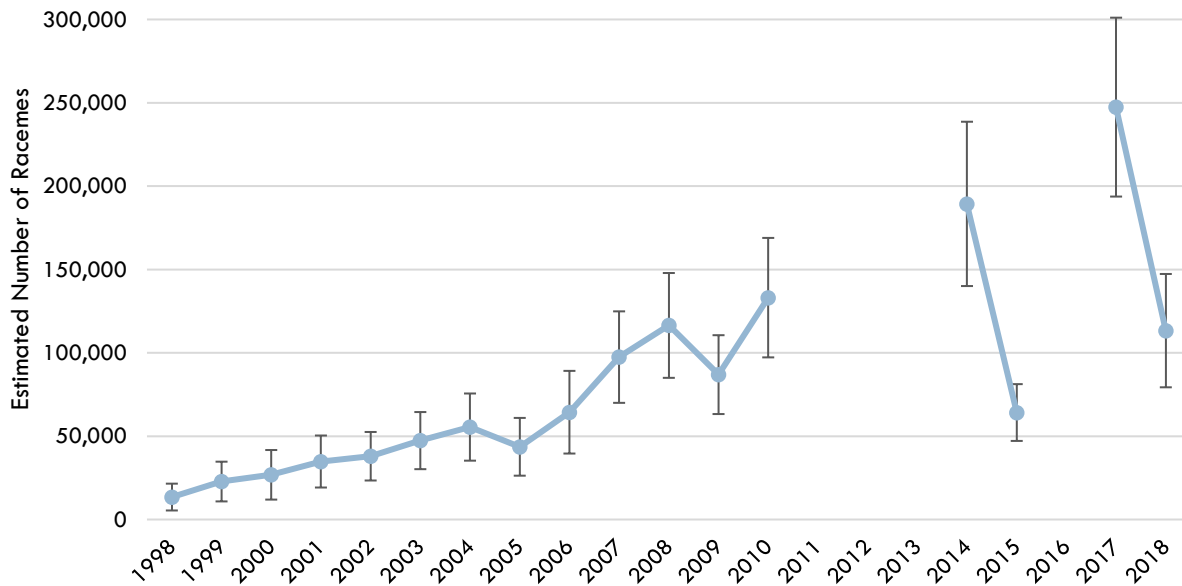


FIGURE 15. ESTIMATED NUMBER OF MATURE LUPINE RACEMES AT FIR BUTTE FROM 1998-2018. DATA WAS NOT RECORDED IN EVERY YEAR.

5.2.2. Community Composition

5.2.2.1. PERCENT COVER OF TARGET WEEDY SPECIES IN KINCAID'S LUPINE PLOTS

The average cover of blackberry in Kincaid's lupine plots in 2018 was 9.9% ($\pm 1.5\%$), lower than that observed in 2015 and 2017 (14.9% $\pm 2.5\%$ and 14.3% $\pm 1.9\%$ respectively), however much of the site had been mowed prior to monitoring, thus the values recorded in 2018 are likely underestimates of the true cover of this species (Table 5). Tall oat grass was also mowed prior to monitoring and again, the observed decreases from 2017 to 2018 (14.6% $\pm 4.9\%$ vs 9.0% $\pm 4.6\%$) are likely due to mowing rather than true decreases in the cover of this introduced graminoid (Table 5).

The presence of meadow knapweed has been observed in a least one transect since 2011. In 2018, the presence of meadow knapweed was observed in two of the 5m sections along the 100m transects. Most meadow knapweed at the site is found outside of areas occupied by Kincaid's lupine, and thus this information is most useful to target areas that could be spot-sprayed or grubbed.

For the first time in 2018, the cover of hedge bindweed was also measured in the 5m sections along the 100m transects. In 2018, this species was only observed in the western portion of the Kincaid's lupine macroplot, with some sub-plots having cover as high as 80%.

TABLE 5. COVER OF HIMALAYAN BLACKBERRY, BRACKEN FERN AND TALL OATGRASS AT FIR BUTTE ALONG 100M X 1M TRANSECTS MONITORED FROM 1998 TO PRESENT. "-" INDICATES THAT DATA WAS NOT COLLECTED IN THAT YEAR.

Year	Average % cover blackberry		Average % cover tall oatgrass*		Average % cover bracken fern	
	Value	95% CI	Value	95% CI	Value	95% CI
1998	21.0	4.6	-	-	-	-
1999	26.6	4.5	-	-	-	-
2000	28.2	5.5	-	-	-	-
2001	13.1	6.0	-	-	-	-
2002	16.4	7.0	-	-	-	-
2003	25.6	9.8	-	-	-	-
2004	11.4	3.0	-	-	-	-
2005	28.6	8.1	-	-	-	-
2006	11.8	2.5	-	-	-	-
2007	7.7	2.1	-	-	-	-
2008	9.8	1.8	-	-	-	-
2009	17.5	3.0	-	-	-	-
2010	13.0	4.1	-	-	-	-
2011	11.5	2.4	-	-	1.7	0.7
2012	-	-	-	-	-	-
2013	-	-	-	-	-	-
2014	17.7	2.1	-	-	4.2	2.1
2015	14.9	2.5	-	-	3.6	1.5
2016	-	-	-	-	-	-
2017	14.3	1.9	14.6	4.9	4.9	2.3
2018**	9.9	1.5	9.0	4.6	3.4	1.7

*Prior to 2017, only presence/absence of tall oatgrass was noted in each of the 5m sections in each 100m transect.

** In 2018, species had been mowed with a string trimmer in the weeks prior to monitoring.

5.2.2.2. PERCENT COVER OF SPECIES IN SE CORNER OF SITE (2018 BURN UNIT)

In 2018, we found that introduced perennial grasses were the dominant species within the 2018 burn unit (the southeast corner), as measured in randomly placed 1m² quadrats (Figure 16). The most common introduced perennial grasses were colonial bentgrass (*Agrostis capillaris*) and tall fescue (*Schedonorus arundinaceus*). Bracken fern and Kincaid's lupine were the most abundant native species with $7.6 \pm 2.6\%$ and $0.7 \pm 0.3\%$ cover, respectively (Table 6). In addition, litter is the most abundant ground cover type with 64.7% ($\pm 2.9\%$).

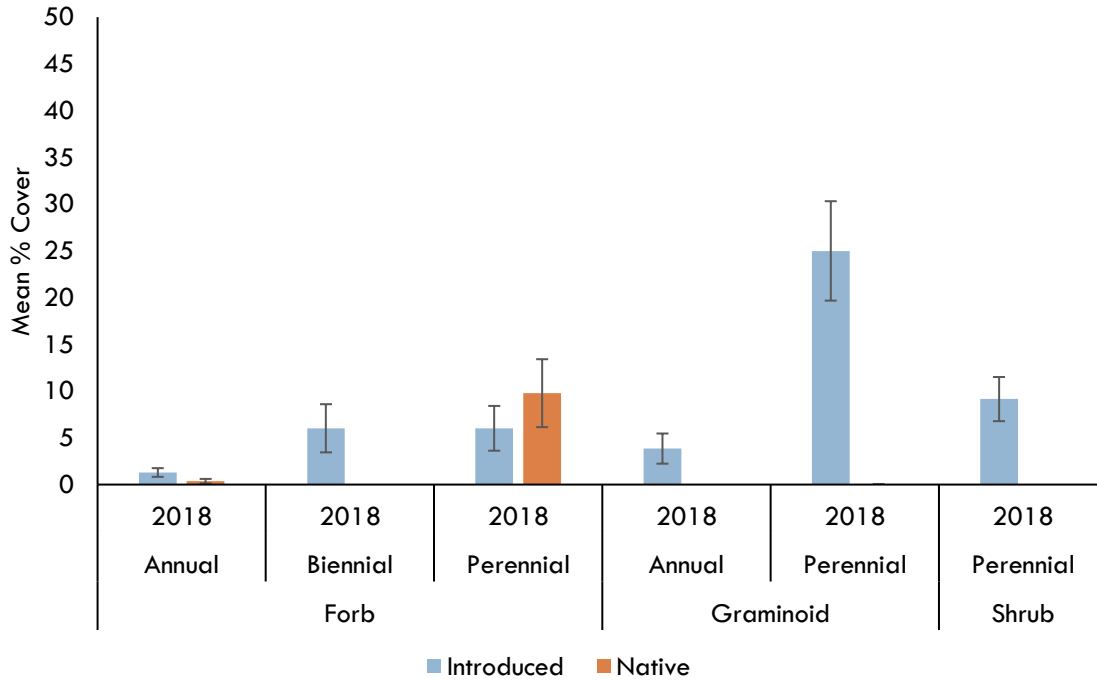


FIGURE 16. MEAN PERCENT (%) COVER OF PLANTS BY GROWTH FORM (FORB, GRAMINOID, OR SHRUB), NATIVITY (INTRODUCED OR NATIVE), AND LIFE HISTORY (ANNUAL, BIENNIAL, OR PERENNIAL) IN 29 1M² QUADRATS IN THE SE CORNER OF FIR BUTTE IN 2018. ERROR BARS REPRESENT 95% CONFIDENCE INTERVALS

TABLE 6. DOMINANT SPECIES RECORDED IN 1M² QUADRATS IN THE SE CORNER AT FIR BUTTE. VALUES IN PARENTHESES REPRESENT 95% CONFIDENCE INTERVALS.

Species	Common name	Growth form	Life history	Nativity	2018 % cover (95% CI)
<i>Agrostis capillaris</i>	colonial bentgrass	Graminoid	Perennial	Introduced	18.9 (2.2)
<i>Festuca arundinacea</i>	tall fescue	Graminoid	Perennial	Introduced	2.5 (1.3)
<i>Arrhenatherum elatius</i>	tall oatgrass	Graminoid	Perennial	Introduced	1.5 (0.6)
<i>Anthoxanthum odoratum</i>	sweet vernalgrass	Graminoid	Perennial	Introduced	1.2 (0.6)
<i>Dactylis glomerata</i>	orchard grass	Graminoid	Perennial	Introduced	0.5 (0.3)
<i>Vulpia</i> sp.	fescue	Graminoid	Annual	Introduced	3.1 (1.1)
<i>Lupinus oreganus</i>	Kincaid's lupine	Forb	Perennial	Native	0.7 (0.3)
<i>Pteridium aquilinum</i>	bracken fern	Forb	Perennial	Native	7.6 (2.6)
<i>Rubus armeniacus</i>	Himalayan blackberry	Shrub	Perennial	Introduced	9.1 (2.4)
<i>Galium parisiense</i>	wall bedstraw	Forb	Annual	Introduced	0.4 (0.2)
<i>Daucus carota</i>	wild carrot	Forb	Biennial	Introduced	0.4 (0.1)

5.3. Monitoring and site assessment discussion

5.3.1. Kincaid's lupine

In 2018 there was a reduction in Kincaid's lupine cover and the count of mature racemes from 2017. The lower than average precipitation in 2018 from January to July, as well as continued competition from non-native species likely contributed to the observed declines. Introduced graminoids continue to expand in distribution through the site, and have maintained high cover despite management treatments.

5.3.2. Vegetation community composition

5.3.2.1. SE CORNER (2018 BURN UNIT)

Plant community data collected in 2018 (percent cover and Relevé) will be used for pre-treatment data for broadcast herbicide applications in the SE corner of the site. Currently non-native grasses and bracken fern are the most abundant species. We expect to see a reduction to these species in the upcoming years as multiple rounds of herbicide treatments, mowing and hand weeding are scheduled. Once cover of non-native grasses and bracken fern is reduced a native seed mix will be sown in the SE corner, tentatively scheduled in 2020.

5.3.2.2. SITE-WIDE MOWING

In previous years, site wide mowing has taken place in mid-September. Mowing expedites thatch decomposition and in general is a positive disturbance for the plant community. However, the timing should be changed to mid-August or whenever Kincaid's lupine has senesced (USFWS 2014, standards 11, 27, 32) so that wild carrot (*Daucus carota*) is mowed to prevent seeds from maturing. The wild carrot

population is rather extensive in the eastern half of the site, particularly in the north section above nectar island 6d (Figure 3). Since wild carrot blooms in late July and through August it may not be detected in summer surveys, especially since it grows in dense patches of tall oatgrass which covers vegetative portions of wild carrot. In addition, we recommend that a flail mower is used rather than a rotary mower. Rotary mowers tend to leave larger windrows than flail mowers, which could reduce seed germination of native species.

6. 2019 PROPOSED ACTIONS

In 2019, IAE proposes that the following habitat restoration and assessment activities are implemented:

- Continue targeted herbicide applications of meadow knapweed throughout the site
- Begin herbicide treatments to Himalayan blackberry, tall oatgrass and oxeye daisy
- Maintain the SE corner in chemical fallow by applying multiple herbicide spot treatments throughout the growing season and conducting a broadcast glyphosate application in the fall
- Continue hand weeding and/or mowing in sensitive areas where herbicide use is not allowed
- Follow up ground disturbing activities (except where chemical fallow is being maintained) with native seeding/plantings
- Monitor the SE corner vegetation to evaluate efficacy of management actions
- If funding is available, monitor the Kincaid's lupine population and overall site habitat quality through the collection of plant community data

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APPENDICES

Appendix 1. Management actions completed at Fir Butte between 2008-2018

Year	Date	Activity	Personnel*	Notes
2008	June-July	Pull tansy ragwort	Land steward	
2008	June-July	Clip seed heads tall oatgrass	Land steward	
2008	June-July	Shade Cloth on meadow knapweed	Land steward	N end, S end, around E small shade cloth patch
2008	June-July	Pull meadow knapweed	Land steward	N end, S end, around E small shade cloth patch
2008		Pull scotch broom, tansy ragwort, tall oatgrass	NWYC	
2008	June-July	Pull meadow knapweed	NWYC	N end, S end, around E small shade cloth patch
2008	April-June	Cut Himalayan blackberry	Land steward	Along fenceline and around shade cloth
2008	April-June	Cut bracken fern	Land steward	
2008	June-July	Cut Ponderosa pine	Land steward	Wetland prairie
2008	August-October	Ecological burn		Wetland and SW third of upland
2008	August-October	Seed nectar mix		Wetland and SW third of upland

Year	Date	Activity	Personnel*	Notes
2009	June-July	Clip seed heads from tall oatgrass	Youth crew	
2009		Pull scotch broom, tansy ragwort, tall oatgrass	Monitoring staff	
2009		Shadecloth, cut meadow knapweed and Himalayan blackberry	Monitoring staff	
2009	August-October	Ecological burn		SE third of upland prairie
2009	August-October	Seed nectar species		SE third of upland prairie
2010	June-July	Pull scotch broom	Monitoring crew	South end
2010	April-July	Pull bracken fern	Monitoring crew	
2010	June-July	Pull purple-anther pepper weed	Monitoring crew	
2010		Pull scotch broom, tansy ragwort, tall oatgrass	Youth crew	
2010		Pull scotch broom, tansy ragwort, tall oatgrass	Youth crew	
2011	April-June	Cut, shadecloth repair	Looking Glass Youth Crew	Eastern border
2011	April-June	Pull bracken fern	Looking Glass Youth Crew	
2011	June-July	Cut woody spp.	Looking Glass Youth Crew	

Year	Date	Activity	Personnel*	Notes
2011	June-July	Pull tansy ragwort	Looking Glass Youth Crew	
2011	August-October	Pull tansy ragwort	Looking Glass Youth Crew	
2011	April-June	Pull bracken fern	NWYC	
2011	August-October	Mastication Himalayan blackberry		
2011	August-October	Prescribed burn		NE third of upland
2011	August-October	Seed nectar mix		NE third of upland prairie, N and S center shade cloth areas, S border
2012	April-June	Apply shadecloth and solarization	Looking Glass Youth Crew	E border of site (See Figure 9, #3)
2012	April-June	Pull scotch broom, tansy ragwort, tall oatgrass	Looking Glass Youth Crew	
2012	June-July	Pull scotch broom, tansy ragwort, tall oatgrass	Looking Glass Youth Crew	
2012	June-July	Apply shadecloth	IAE, Looking Glass Youth Crew	5 8m x 10m areas dispersed throughout site
2012	October	Prescribed burn		6 acres: Wetland and NE third of upland
2012	October	Seed wetland and upland species mix	IAE	Burned area

Year	Date	Activity	Personnel*	Notes
2012	October	Plant nectar species	IAE, Looking Glass Youth Crew	Shadecloth and solarization area on E border of site (Figure 9, #3)
2013	17-Apr	Marking of weeds site wide	IAE	Systematically began wandering through site and marking locations of <i>Cirsium vulgare</i> , <i>Cytisus scoparius</i> , <i>Centaurea x pratensis</i> , <i>Lepidium heterophyllum</i> , <i>Hypericum perforatum</i> , and <i>Senecio jacobaea</i> .
2013	23-Apr	Finish marking weeds	IAE	Systematically wandered through rest of site and marked all locations of the species listed from 4/17.
2013	25-Apr	Hand removal of weeds throughout site	IAE	Digging/pulling of all weeds marked on 4/17/13
2013	29-Apr	Hand removal of weeds throughout site	IAE	Digging/pulling of all weeds marked on 4/17/13
2013	1-May	Post-treatment data on shadecloth/solarization plots	IAE	Recorded species and cover information in 10 plots per treatment area, 30 plots total. Took photograph of all points.
2013	1-May	Pre-treatment data on new shadecloth areas	IAE	Took pre-treatment data on shadecloth areas to be placed with youth crew the next week
2013	10-May	Weed whacking, tilling prior to solarization	IAE	Weed whacked all new shadecloth plots in preparation for youth crew. Weed whacked 2m wide perimeter around all shadecloth plots. Tilled 3 of the 4 plots that are to receive solarization next week.

Year	Date	Activity	Personnel*	Notes
2013	14, 15, 22-May	Shadecloth/solarization installation	IAE, Looking Glass Youth Crew	
2013	19-Jun	Weed whacking tall oatgrass, hand weeding solarization plots	IAE, NWYC crew of 6	Weed whacked tall oatgrass. Started in NE corner and moved south along east boundary to SE corner. Moved west across southern border to middle. Walked north through middle whacking small patches. Did not whack big patch in SW corner nor small patches in north-middle.
2013	19-Jun	Hand weeding solarization plots	IAE, NWYC crew of 6	Hand weeded starting in SW corner of shadecloth/solarization experiment area....did not make much progress....very slow growing...attempted to be thorough but realized by end of the day that it is impractical with this density of <i>Agrostis capillaris</i> and <i>Rumex acetosella</i> colonization
2013	10-Jul	Weeding	IAE	Hand weeded in shadecloth/solarization experiment area. Focused largely on removing seed heads of velvet grass and sheep sorrel. 5 contractor bags full.
2013	16-Sep	Solarization removal	IAE	Upon arrival, found that the plastic on all four solarization plots was shredded and the plots were no longer covered. Perhaps fault of heat or lack of UV stabilizer in plastic. Cleaned up 2 of the 4 plots.

Year	Date	Activity	Personnel*	Notes
2013	16-Sep	Purple anther pepper weed weeding	IAE	In large shadecloth/solarization experiment plot, dug out all visible <i>Lepidium heterophyllum</i> plants that had set seed this year. Small plants in leaf were generally not removed. Lots of dry seed on the plants.
2013	18-Sep	T-post replacement, East edge	IAE	Replaced all T-posts near east edge of property with orange cement markers. The only T-post that had a tag on it was the one in the far SE corner; it was transferred to the new marker. T-posts appeared to be regularly spaced in southern 2/3 of property, but were sparse and irregular in northern 1/3.
2013	18-Sep	T-post replacement, middle	IAE	Began replacing T-posts in middle of property. Started at north end and replaced all green transect T-posts. Put metal scratch tag on all new concrete markers that says 'transect'. For the red plot marker T-posts, replaced #824, 819, and 818 (transferred tags), left #826, 820 in place, and couldn't locate #825, 821-823.
2013	18-Sep	Meadow knapweed weeding	IAE	Clipped seed heads on meadow knapweed along north border and east of big shadecloth area.
2013	18-Sep	Wooden post removal	IAE	Removed 2 wooden posts with signs along E edge and placed on nearby shadecloth plots.

Year	Date	Activity	Personnel*	Notes
2013	18-Sep	Large shadecloth alteration	IAE	Lifted east edge of big shadecloth and folded over so that there will be room to get mower past.
2013	18-Sep	Solarization removal	IAE	Removed shredded plastic at the remaining 2 solarization plots.
2013	30-Sep	Solarization raking, shadecloth removal, weed whacking around plots	IAE	Raked all four solarization plots to refill trenches. Weed whacked around all solarization/shadecloth plots because mower will not be able to mow close to plots/stakes. Removed shadecloth on plots 1a and on small lepidium shadecloth plot. Noticed that tall oatgrass in areas that were weed whacked on 5/10 was able to reflower much more than areas mowed on 6/19.
2013	31-Oct	Flame weeding	IAE	Flame weeded plots 1a-5a.
2013	1-Nov	Plant delivery	IAE	Picked up plants at Eugene NPN and Heritage and delivered to Fir Butte
2013	4-Nov	Planting	IAE, Lane Metro Youth Corps	Planted in plots 2a, 3a, 4a, and "lepidium". See planting summary for details, Table 3 and Figure 4.

Year	Date	Activity	Personnel*	Notes
2013	6-Nov	Seeding	IAE	Seeded over plots 2a, 3a, 4a, "lepidium", and Experiment A-C.
2013	20-Nov	Shade cloth removal	IAE	plot 6a
2013	20-Nov	Flame weeding	IAE	plot 6a
2014	20-Mar	Flame weeding	IAE	Flame weeded plots 1a, 5a, 6
2014	20-May	Flame weeding	IAE	Flame weeded plots 1a, 5a, 6
2014	5, 6-Jun	Hand mow tall oatgrass	IAE, 4 people from Walama	Hand mowed tall oatgrass at 6" throughout site. Where growing concurrently with <i>Lupinus oreganus</i> , mowed above top of raceme. At Cheryl Schultz' request did not finish L shape patch in SW corner. (Figure 2)
2014	6-Jun	Monitoring	IAE	Monitored shadecloth/solarization experimental plots
2014	17, 18-Jun	Hand weeding	IAE, 12 from NWYC	plots 2a, 3a, 4a
2014	17, 18-Jun	Hand mow tall oatgrass	IAE, 12 from NWYC	finished work started by Walama on 6/5 and 6/6

Year	Date	Activity	Personnel*	Notes
2014	17, 18-Jun	Hand weeding bracken fern	IAE, 12 from NWYC	focused on area about 200 feet west of plot 2a around <i>Lupinus oreganus</i>
2014	12-Sep	Preparation for new fence construction	IAE	Removed E border T-posts and barbed wire; mowed 15 foot wide blackberries and grass up against fence.
2014	12-Sep	Remowed fire line	IAE	N edge of prescribed burn area; preparation for burn
2014	22-Sep	Fence construction	Island Fence	Fence constructed along entire east border of property
2014	29-Oct	Flame weeding	IAE	Flame weeded plots 1 a, 5a. Did not reflare plot 6 because excessive weedy grasses had established.
2014	3, 5-Nov	Planting	IAE, Lane Metro Youth Corps	planted plugs and bulbs in plots 1a, 5a, 3b
2014	24-Nov	Planting	IAE, Americorps	finished planting plugs and bulbs in plots 1a, 3b, 5a
2014	24-Nov	Weeding	IAE	weeded most velvet grass out of 1a
2015	14-Jan	Seeding	IAE	overseeded plots 1a, 3b, 5a, and burned area
2015	24-Mar	Orientation visit	IAE	New IAE staff visited site for first time, observed nectar islands and got an overview of the site from Christine

Year	Date	Activity	Personnel*	Notes
2015	23-Apr	Orientation visit; hand pull & dig weeds	IAE	Removed meadow knapweed rosettes, <i>Lepidium</i> , thistle, tansy ragwort in northern portion of site
2015	6-May	Remove weeds	IAE	Removed meadow knapweed rosettes, <i>Lepidium</i> , thistle, tansy ragwort throughout site
2015	12-May	Monitoring	IAE	Collected data from shadecloth/solarization test plots
2015	13-May	Removed weeds	IAE	Removed <i>Lepidium</i> from plot 6, weeded invasive grasses from nectar islands
2015	26, 27-May	Hand mow tall oatgrass	IAE, 2 people from Walama Restoration	Hand mowed tall oatgrass at 6" throughout site (Figure 2). Where growing concurrently with <i>Lupinus oregonus</i> , mowed above top of raceme. Did not mow Cheryl Schultz's research plots in the SW corner.
2015	12-Jun	Nectar island weeding	IAE	Mowed edges of all nectar islands and Experiments A, B, and C. Weeded velvetgrass out of all nectar islands (except 6, which was excessively weedy).
2015	5-Aug	Hand weeding	IAE	Hand weeded and bagged meadow knapweed, mainly in the NW corner
2015	7-Aug	Hand weeding	IAE	Removed blackberry from edges of nectar islands, weeded nectar islands

Year	Date	Activity	Personnel*	Notes
2015	9-Nov	Planting	IAE, Looking Glass Youth Crew	Planted plugs and bulbs in plot 4b
2015	10-Nov	Planting	IAE, Looking Glass, AmeriCorps crew	Planted plugs, bulbs, and runners in plots 4b, 5b and 2b, moved shadecloth to plots 4c, 1c, 2c, and 5c,
2015	13-Nov	Planting	IAE, 4 volunteers	Planted plugs and bulbs in plots 1b and 2b
2015	19-Nov	Planting	IAE	Planted plugs and bulbs in plots 2b and 5b
2015	3-Dec	Planting, weeding	IAE,, AmeriCorps crew	Planted strawberry runners in plots 1b, 5b, and 2b weeded <i>agrostis</i> from 1a
2015	8-Dec	Seeding	IAE	Overseeded plots 1a, 1b, 2b, 4b, 5a, and 5b
2016	31-Mar	Herbicide application	IAE	Applied Fusilade herbicide to four experimental plots to test non-target impact of using Fusilade to manage prairie harboring Fender's blue butterfly

Year	Date	Activity	Personnel*	Notes
2016	19, 20-April	Hand weeding	IAE, Looking Glass crew	Hand-weeded meadow knapweed (<i>Centaurea pratensis</i>), Purpleanther field pepper weed (<i>Lepidium heterophyllum</i>), bull thistle (<i>Cirsium vulgare</i>), tansy ragwort (<i>Senecio jacobea</i>) in northern portion of site; removed hairy cat's ear (<i>Hypochaeris</i> spp.), sheep sorrel (<i>Rumex acetosella</i>), and bentgrasses (<i>agrostis</i> spp.) from nectar islands
2016	6-May	Survey for Fender's blue butterfly	IAE and BLM	Distance sampling for Fender's blue butterfly
2016	27-May	Hand mow tall oatgrass	IAE	Hand mowed tall oatgrass at 6" throughout site. Where growing concurrently with Kincaid's lupine, mowed above top of raceme. Did not mow Cheryl Schultz's research plots in the SW corner.
2016	2-Jun	Hand mow tall oatgrass	IAE	Hand mowed tall oatgrass at 6" throughout site. Where growing concurrently with Kincaid's lupine, mowed above top of raceme. Did not mow Cheryl Schultz's research plots in the SW corner.
2016	26-Jul	Hand weeding	BLM and Looking Glass crew	Hand weeded and bagged meadow knapweed, mainly in the NW corner
2016	17-Aug	Hand weeding	IAE and BLM	Removed Himalayan blackberry (<i>Rubus armeniacus</i>) from edges of nectar islands, weeded nectar islands

Year	Date	Activity	Personnel*	Notes
2016	22-Aug	Burn break prep	IAE and BLM	Mowed edges of Schultz research plots to prepare for prescribed burn.
2016	22-Aug	Shadecloth	IAE and BLM	Replaced shadecloth on nectar island 2c.
2016	2-Sep	Fire break prep	IAE	Removed tree on the edge of fire break on Schultz research plot.
2016	16-Sep	Prescribed burn	Inter-Agency burn crew	Burned 4 acres in SE corner; burned 8 research plots in SW corner.
2016	19-Oct	Seeding	BLM	Seeded burn unit with native mix
2016	8-Nov	Planting	IAE, BLM, Looking Glass, AmeriCorps, volunteer	Planted bulbs and bareroot lomatium in plots 1c, 2c, 4c & 5c
2016	21-Nov	Planting	IAE, BLM, Looking Glass, AmeriCorps, volunteer	Planted plugs and bulbs in plots 4c, 1c, 2c, and 5c
2016	29-Nov	Seeding	IAE	Overseeded plots 1a, 1b, 1c, 2a, 2b, 2c, 3a, 3b, 4a, 4b, 4c, 5a, 5b, 5c
2017	23-Mar	Herbicide application	Habitat Restoration LLC	Applied Fusilade herbicide to four experimental plots to test non-target impact of using Fusilade to manage prairie harboring Fender's blue butterfly
2017	May-July	Survey for Fender's blue butterfly	BLM	Distance sampling for Fender's blue butterfly

Year	Date	Activity	Personnel*	Notes
2017	13-Jul	Weed removal	BLM and Looking Glass	Removed meadow knapweed inflorescences
2017	6-Jun	Hand mow tall oatgrass	IAE and BLM	Hand mowed tall oatgrass at 6" throughout site. Where growing concurrently with Kincaid's lupine, mowed above top of raceme. Did not mow Cheryl Schultz's research plots in the SW corner
2017	13-Sep	Nectar island prep	IAE and BLM	Cleared and prepared shade cloth for nectar species planting
2017		Fire break prep	Contractor	Mowed fire brake around burn zone
2017	13-Sep	Fire break prep	IAE and BLM	Delineated burn zone with pin flags
2017	5-Oct	Prescribed burn	Inter-Agency burn crew	Burned 4 acres in north section which contain both upland and wet prairies
2017	19, 26-Oct	Nectar island prep	IAE and BLM	Burned 1710 holes in shadecloth and seeded with native mix
2017	24-Oct	Seeding	IAE and BLM	Seeded wet prairie with native mix
2017	26-Oct	Seeding	IAE and BLM	Seeded upland with native mix
2017	8-Nov	Planting	IAE, BLM, and Looking Glass	Planted 400 Kincaid's lupine plugs at Hansen

Year	Date	Activity	Personnel*	Notes
2017	14-Nov	Planting	BLM and Looking Glass	Planted approximately 1200 <i>Fragaria virginiana</i> runners
2017	15-Nov	Planting	IAE, BLM and Looking Glass	Planted approximately 1600 <i>Triteleia hyacinthine</i> bulbs
2017	20-Nov	Planting	IAE	Planted 50 pots of <i>Eriophyllum lanatum</i> and <i>Sidalcea malviflora</i> , respectively in the upland area of the burn zone
2017	20-Nov	Nectar island prep	IAE and BLM	Burned holes in weed barrier
2017	21-Nov	Planting	IAE and BLM	Planted 200 <i>Eriophyllum lanatum</i> , 300 <i>Sidalcea malviflora</i> pots, ~300 <i>Camassia leichtlinii</i> and ~300 <i>Allium amplexans</i> bulbs and a native seed mix in the nectar island
2018	20-Mar	Herbicide application	Habitat Restoration LLC	Applied Fusilade herbicide to four experimental plots to test non-target impacts of using Fusilade to manage prairie harboring Fender's blue butterfly
2018	18-Apr	Weed control	IAE	Flame weeded meadow knapweed in NW corner
2018	18-Apr	Weed control	IAE/BLM/LGYC	Picked bracken fern on south east side
2018	8-May	Weed control	LGYC	Picked bracken fern on south east side
2018	17-May	Site preparation	IAE/BLM	Flame weeded a 9x8m plot for nectar island establishment and covered plot with plastic for solarization treatment
2018	21-May	Weed control	IAE	Mowed bracken fern

Year	Date	Activity	Personnel*	Notes
2018	29-May	Weed control	IAE/BLM	Mowed tall oatgrass with string trimmer
2018	30-May	Weed control	IAE	Mowed tall oatgrass with string trimmer
2018	1-Jun	Weed control/site preparation	IAE	Mowed tall oatgrass with string trimmer and put plastic on nectar island
2018	5-Jun	Weed control	IAE	Mowed tall oatgrass with string trimmer
2018	8-Jun	Weed control	IAE	Mowed tall oatgrass with string trimmer
2018	8-Jun	Site preparation	IAE	Established a new 6X20m nectar island by clearing off vegetation with a string trimmer
2018	9-Jun	Site preparation	IAE	Covered mowed nectar island with plastic for solarization treatment
2018	13-Jun	Weed control	IAE	Mowed meadow knapweed in northwest corner
2018	26-Jun	Weed control	IAE	Pulled knapweed
2018	10-Jul	Weed control	IAE	Pulled Knapweed
2018	26-Jul	Weed control	IAE	Pulled Knapweed
2018	14-Aug	Site preparation	IAE	Flagged nectar islands
2018	27-Aug	Weed control	Contractor	Site wide mowing (except for burn unit and nectar islands)
2018	6-Sep	Site preparation	IAE/BLM	Removed plastic from solarization treatments

Year	Date	Activity	Personnel*	Notes
2018	2-Oct	Weed control	IAE/BLM/LGYC	Removed Scotch broom from SE corner
2018	13-Oct	Prescribed burn	Interagency team	Burned approximately 5-acres in SE corner and all nectar islands
2018	17-Oct	Seeding	IAE	Broadcast nectar island seed mix over nectar islands
2018	7-Dec	Herbicide application	Contractor	Integrated Resource Management broadcast a 1.5% glyphosate solution over the 3-acre burn unit in the SE corner and over a small patch to the west of nectar islands 4c/4b
2018	7-Dec	Herbicide application	IAE	Applied 1.5% glyphosate solution to meadow knapweed across the site using a backpack sprayer.

* Institute for Applied Ecology (IAE), Bureau of Land Management (BLM), Looking Glass Youth Crew (LGYC), Northwest Youth Crew (NWYC)

Appendix 2. Prescribed burn locations at Fir Butte between 2008- 2018



Appendix 3. Plant materials added to nectar islands between 2014-2018

2014

Species	Form	Plot 1a	Plot 3b	Plot 5a
<i>Eriophyllum lanatum</i>	1'x2' Flats	62	62	62
<i>Sidalcea malviflora</i> spp. <i>virgata</i>	Heritage medium plug trays	440	320	320
<i>Lomatium nudicaule</i>	Bare root	233	233	233
<i>Allium amplexens</i>	Bare root bulbs	550	550	550
<i>Festuca roemerii</i>	Heritage medium plug trays	160	320	320
<i>Luzula comosa</i>	Heritage medium plug trays	91	91	91
<i>Camassia leichtlinii</i>	Bulbs in 1'x2' flats	3 trays	3 trays	4 trays
<i>Zigadenus venenosus</i>	Bulbs in 1'x2' flats	3 trays	2 trays	3 trays
<i>Triteleia hyacinthina</i>	Bulbs in 1'x2' flats		1 tray	

Species	Total lbs. in plots 1a, 3b and 5a combined
<i>Achillea millefolium</i>	0.06
<i>Camassia leichtlinii</i>	1.31
<i>Clarkia purpurea</i> ssp. <i>quadrivulnera</i>	0.02
<i>Epilobium densiflorum</i>	0.05
<i>Eriophyllum lanatum</i>	0.07
<i>Festuca roemerii</i>	0.35
<i>Linanthus bicolor</i>	0.02
<i>Luzula comosa</i>	0.09
<i>Microseris laciniata</i>	0.10
<i>Plectritis congesta</i>	0.07
<i>Potentilla gracilis</i>	0.03
<i>Prunella vulgaris</i> var. <i>lanceolata</i>	0.16
<i>Sidalcea virgata</i>	0.49
<i>Wyethia angustifolia</i>	0.66
Total	3.49

2015

Species	Form	Plot 1b	Plot 2b	Plot 4b	Plot 5b
<i>Iris tenax</i>	4" pots	10	10	10	10
<i>Sisyrinchium idahoense</i>	4" pots	20	20	20	20
<i>Eriophyllum lanatum</i>	Small band pots	15	15	15	15
<i>Sidalcea malviflora</i> spp. <i>virgata</i>	Heritage medium plug trays	640	640	640	640
<i>Allium amplexans</i>	Bulbs in 1' x 2' flats (100 bulbs per flat)	1.75 trays	1.75 trays	1.75 trays	1.75 trays
<i>Festuca roemerii</i>	Heritage medium plug trays	612	612	612	612
<i>Zigadenus venenosus</i>	Bulbs in 1'x2' flats (100 bulbs per flat)	1.25 trays	1.25 trays	1.25 trays	1.25 trays
<i>Fragaria virginiana</i>	Ramets	250	250	250	250

Species	Total seed (lbs) plots 1b, 2b, 4b and 5b combined
<i>Achillea millefolium</i>	0.09
<i>Camassia leichtlinii</i>	1.61
<i>Clarkia purpurea</i> ssp. <i>quadrivulnera</i>	0.02
<i>Epilobium densiflorum</i>	0.07
<i>Eriophyllum lanatum</i>	0.23
<i>Festuca roemerii</i>	0.52
<i>Linanthus bicolor</i>	0.02
<i>Lomatium nudicaule</i>	0.22
<i>Microseris laciniata</i>	0.12
<i>Nemophila menziesii</i> var. <i>atomaria</i>	0.06
<i>Plectritis congesta</i>	0.51
<i>Potentilla gracilis</i>	0.40
<i>Prunella vulgaris</i> var. <i>lanceolata</i>	0.18
<i>Sidalcea virgata</i>	0.83
<i>Wyethia angustifolia</i>	0.75
Total seed (lbs)	5.22
Total Forb seed (lbs)	4.7
Total Graminoid seed (lbs)	0.52

2016

Species planted		Form	Plot 1c	Plot 2c	Plot 4c	Plot 5c
Scientific name	Common name		Numbers of plants			
<i>Sidalcea malviflora</i> spp. <i>virgata</i>	dwarf checkermallow	Medium plugs	400	400	400	400
<i>Allium amplexans</i>	narrowleaf onion	Bulbs	375	375	375	375
<i>Festuca roemerii</i>	Roemer's fescue	Medium plugs	100	100	100	100
<i>Luzula comosa</i>	Pacific woodrush	Medium plugs	200	200	200	200
<i>Lomatium nudicaule</i>	barestem desert parsley	Bareroot stems	800	800	500	500
Total number of plants			1875	1875	1575	1575

Scientific name	Common name	Total seed (PLS in lbs)
<i>Achillea millefolium</i>	yarrow	0.20
<i>Camassia leichtlinii</i>	large camas	1.59
<i>Clarkia purpurea</i>	farewell to spring	0.06
<i>Epilobium densiflorum</i>	denseflower willowherb	0.09
<i>Eriophyllum lanatum</i>	Oregon sunshine	0.17
<i>Festuca roemerii</i>	Roemer's fescue	0.84
<i>Linanthus bicolor</i>	true babystars	0.02
<i>Lomatium nudicaule</i>	barestem desert parsley	0.19
<i>Microseris laciniata</i>	cutleaf silverpuffs	0.17
<i>Nemophila menziesii</i> var. <i>atomaria</i>	baby blue eyes	0.05
<i>Plectritis congesta</i>	shortspur seablush	0.21
<i>Potentilla gracilis</i>	slender cinquefoil	0.07
<i>Prunella vulgaris</i> var. <i>lanceolata</i>	lance selfheal	0.31
<i>Sidalcea malviflora</i> spp. <i>virgata</i>	dwarf checkermallow	0.83
<i>Wyethia angustifolia</i>	California compassplant	0.48
Total seed (lbs)		5.28
Total area seeded (acres)		0.28

* Seed mix broadcasted over plots 1a, 1b, 1c, 2a, 2b, 2c, 3a, 3b, 4a, 4b, 4c, 5a, 5b, and 5c in fall 2016.

2017

Species	Common name	Quantity
<i>Allium amplexens</i>	Narrowleaf onion	Approximately 300 plugs
<i>Camassia leichtlinii</i>	Suksdorf's large camas	Approximately 300 plugs
<i>Eriophyllum lanatum</i> var. <i>lanatum</i>	wooly sunflower	250 band pots
<i>Sidalcea malviflora</i> ssp. <i>virgata</i>	Rose checkermallow	350 band pots

Species	Common name	Pounds/Acre
<i>Achillea millefolium</i>	yarrow	0.2
<i>Camassia leichtlinii</i> var. <i>suksdorfii</i>	Suksdorf's large camas	1.59
<i>Clarkia purpurea</i>	purple clarkia	0.06
<i>Epilobium densiflorum</i>	denseflower willowherb	0.09
<i>Eriophyllum lanatum</i> var. <i>lanatum</i>	wooly sunflower	0.17
<i>Festuca roemerii</i>	Roemer's fescue	0.84
<i>Linanthus bicolor</i>	true babystar	0.02
<i>Lomatium nudicaule</i>	barestem biscuitroot	0.2
<i>Microseris laciniata</i>	cutleaf silverpuffs	0.17
<i>Nemophila menziesii</i> var. <i>atomaria</i>	baby blue eyes	0.11
<i>Plectritis congesta</i>	shortspur seablush	0.21
<i>Potentilla gracilis</i> var. <i>gracilis</i>	slender cinquefoil	0.07
<i>Prunella vulgaris</i> var. <i>lanceolata</i>	self-heal	0.31
<i>Sidalcea malviflora</i> ssp. <i>virgata</i>	dwarf checkerbloom	0.83
<i>Wyethia angustifolia</i>	California compassplant	0.48

* Approximately two tablespoons of seed mix was put in unoccupied holes in the weed barrier.

2018

Species	Common name	Pounds/Acre
<i>Achillea millefolium</i>	common yarrow	0.1
<i>Allium amplexans</i>	narrowleaf onion	1.2
<i>Camassia leichtlinii</i>	Suksdorf's large camas	5.01
<i>Eriophyllum lanatum</i>	wooly sunflower	0.81
<i>Lomatium nudicaule</i>	barestem biscuitroot	1.21
<i>Luzula comosa</i>	Pacific woodrush	0.12
<i>Microseris laciniata</i>	cutleaf silverpuffs	0.29
<i>Plectritis congesta</i>	shortspur seablush	0.2
<i>Prunella vulgaris</i>	self-heal	0.34
<i>Ranunculus occidentalis</i>	Western buttercup	0.44
<i>Sidalcea malviflora</i>	rose checkermallow	4
<i>Sisyrinchium idahoense</i>	Idaho blue-eyed grass	0.22

*Seed mix was broadcast over plots 1a, 1b, 1c, 2a, 2b, 2c, 4a, 4b, 4c, 5a, 5b and the new plots created in 2018.

Appendix 4. Foliar cover, number of leaves, number of mature racemes, and racemes/m² of Kincaid's lupine from 1998-2018.

Year	Estimated # of leaves		Estimated foliar cover (m ²)		Estimated # of mature racemes		Racemes/m ²
	Value	95% CI	Value	95% CI	Value	95% CI	
1998	223,780	±124,773	-		13,468	±8,052	-
1999	364,506	±212,576	-		22,776	±11,913	-
2000	431,283	±247,315	-		26,821	±14,870	-
2001	635,720	±332,041	-		34,800	±15,599	-
2002	816,571	±409,937	-		37,963	±14,558	-
2003	764,355	±360,055	-		47,335	±17,138	-
2004	1,424,524	±678,553	1,440	±685	55,456	±20,147	39
2005	861,633	±448,592	1,185	±539	43,624	±17,324	37
2006	-		1,421	±683	64,377	±24,799	45
2007	-		1,591	±728	97,437	±27,446	61
2008	-		1,592	±732	116,438	±31,446	73
2009	-		1,730	±686	86,921	±23,654	50
2010	-		2,605	±1,139	133,113	±35,837	51
2011	-		2,396	±703	-		-
2012	-		-		-		-
2013	-		-		-		-
2014	-		3,106	±872	189,354	±49,295	61
2015	-		3,555	±927	64,183	±17,037	18
2016	-		-		-		-
2017	-		4,834	±1,170	247,412	±53,661	51
2018	-		3,352	±838	113,313	±33,995	34

Appendix 5. Cover, sociability classes and midpoint of cover values in Relevé plots at Fir Butte in June 2018 prior to herbicide treatments.

Plots A and B

Ground Cover	A-south			B-South			B-north		
	Cover	Soc.	Midpt.	Cover	Soc.	Midpt.	Cover	Soc.	Midpt.
bare ground	1		3.0	R		0.1	2		15.0
litter	2		15.0	2		15.0	2		15.0
rock							R		0.1
moss									
Species									
<i>Achillea millefolium</i>	1	4	3.0	+	5	0.7	+	5	0.7
<i>Allium amplexans</i>	R	5	0.1	R	5	0.1	R	5	0.1
<i>Allium</i> sp.									
<i>Camassia</i> sp.	R	5	0.1						
<i>Centaurea pratensis</i>									
<i>Centaureum erythraea</i>	R	5	0.1				R	5	0.1
<i>Cirsium vulgare</i>	R	5	0.1						
<i>Clarkia species</i>	+	5	0.7	+	5	0.7	R	5	0.1
<i>Collomia grandiflora</i>	R	5	0.1				R	5	0.1
<i>Crepis capillaris</i>	+	5	0.7				+	5	0.7
<i>Daucus carota</i>	1	5	3.0	1	5	3.0	2	5	15.0
<i>Dichelostemma congestum</i>	R	5	0.1						
<i>Epilobium ciliatum</i>									
<i>Eriophyllum lanatum</i>	3	2	37.5	1	2	3.0	2	4	15.0
<i>Fragaria virginiana</i>				R	5	0.1			
<i>Galium aparine</i>									
<i>Galium parisiense</i>	+	4	0.7						
<i>Geranium dissectum</i>									
<i>Gilia capitata</i>	R	5	0.1						
<i>Hypericum perforatum</i>				R	5	0.1	R	5	0.1
<i>Hypochaeris radicata</i>				1	5	3.0	+	5	0.7
<i>Lathyrus sphaericus</i>	R	5	0.1						
<i>Lepidium</i> sp.				R	5	0.1			
<i>Linum bienne</i>	R	5	0.1						
<i>Lomatium nudicaule</i>	R	5	0.1				R	5	0.1
<i>Lotus micranthus</i>									
<i>Lotus unifoliolatus</i>	R	5	0.1						
<i>Lupinus oreganus</i>									
<i>Madia sativa</i>	R	5	0.1						
<i>Parentucellia viscosa</i>				2	3	15.0	2	3	15.0
<i>Plantago lanceolata</i>	+	5	0.7						

Ground Cover	A-south			B-South			B-north		
	Cover	Soc.	Midpt.	Cover	Soc.	Midpt.	Cover	Soc.	Midpt.
<i>Potentilla gracilis</i>				R	5	0.1			
<i>Prunella vulgaris</i>	1	3	3.0				2	3	15.0
<i>Pteridium aquilinum</i>							+	5	0.7
<i>Rubus armeniacus</i>	1	4	3.0	+	5	0.7	2	4	15.0
<i>Rumex acetosella</i>	2	4	15.0	1	4	3.0	+	5	0.7
<i>Senecio jacobaea</i>									
<i>Sidalcea species</i>	1	5	3.0	1	5	3.0	2	5	15.0
<i>Toxicodendron diversilobum</i>									
<i>Vicia hirsuta</i>	+	5	0.7	R	5	0.1	R	5	0.1
<i>Vicia sativa</i>				R	5	0.1	R	5	0.1
<i>Agrostis capillaris</i>	3	2	37.5	4	2	62.5	2	3	15.0
<i>Aira caryophylla</i>	R	5	0.1				R	5	0.1
<i>Anthoxanthum odoratum</i>	1	4	3.0	+	4	0.7			
<i>Arrhenatherum elatior</i>	+	4	0.7						
<i>Avena fatua</i>							R	5	0.1
<i>Bromus hordeaceus</i>	1	5	3.0	+	5	0.7	R	5	0.1
<i>Bromus rigidus</i>	R	5	0.1				R	5	0.1
<i>Cynosurus echinatus</i>	R	5	0.1	R	5	0.1	R	5	0.1
<i>Danthonia</i>				R	5	0.1			
<i>Festuca arundinacea</i>	R	4	0.1						
<i>Festuca roemerii</i>	1	4	3.0	1	4	3.0	2	4	15.0
<i>Holcus lanatus</i>	R	5	0.1						
<i>Luzula sp.</i>	R	5	0.1				R	5	0.1
<i>Vulpia bromoides</i>	+	5	0.7				R	5	0.1
<i>Vulpia sp.</i>				R	5	0.1			
Forb Total			68.9			31.8			79.1
Native Forb			47.9			7.6			46.7
Introduced Forb			21.0			24.2			32.4
Graminoid Total			48.3			67.1			30.6
Native Graminoid			3.1			3.1			15.1
Introduced Graminoid			45.3			64.1			15.6
Tree/Shrub			3.0			0.7			15.0

Plots C, D and E

	Area C			Area D	E-north			E-south		
	Cover	Soc.	Midpt.	Avg. Cover	Cover	Soc.	Midpt.	Cover	Sociability	Midpoint
bare ground	2		15.0	1.0	1		3.0	R		0.1
litter	1		3.0	64.7	1		3.0	4		62.5
rock										
moss					R		0.1			
<i>Achillea millefolium</i>	1	5	3.0		1	5	3.0	R	5	0.1
<i>Allium amplexans</i>	R	5	0.1		R	5	0.1	R	5	0.1
<i>Allium sp.</i>								R	5	0.1
<i>Camassia sp.</i>										
<i>Centaurea pratensis</i>	R	5	0.1							
<i>Centaureum erythrea</i>										
<i>Cirsium vulgare</i>	R	5	0.1							
<i>Clarkia species</i>	2	5	15.0		1	5	3.0			
<i>Collomia grandiflora</i>										
<i>Crepis capillaris</i>	1	5	3.0	5.6	1	5	3.0			
<i>Daucus carota</i>	+	5	0.7	0.4	2	5	15.0	1	5	3.0
<i>Dichelostemma congestum</i>								R	5	0.1
<i>Epilobium ciliatum</i>										
<i>Eriophyllum lanatum</i>	2	2	15.0	0.3	2	4	15.0			
<i>Fragaria virginiana</i>										
<i>Galium aparine</i>										
<i>Galium parisiense</i>				0.4						
<i>Geranium dissectum</i>				0.1						
<i>Gilia capitata</i>										
<i>Hypericum perforatum</i>										
<i>Hypochaeris radicata</i>	R	5	0.1	3.2	1	5	3.0	R	5	0.1
<i>Lathyrus sphaericus</i>										
<i>Lepidium sp.</i>										
<i>Linum bienne</i>										
<i>Lomatium nudicaule</i>					R	5	0.1	R	5	0.1
<i>Lotus micranthus</i>	R	5	0.1	0.3						
<i>Lotus unifoliolatus</i>										
<i>Lupinus oregonus</i>	+	5	0.7	0.7						
<i>Madia sativa</i>				0.0						
<i>Parentucellia viscosa</i>	2	3	15.0	0.6	2	5	15.0	R	5	0.1
<i>Plantago lanceolata</i>	+	5	0.7							
<i>Potentilla gracilis</i>										
<i>Prunella vulgaris</i>	1	4	3.0	0.1	2	5	15.0			
<i>Pteridium aquilinum</i>				7.6						
<i>Rubus armeniacus</i>	+	5	0.7	9.1	1	4	3.0	+	5	0.7
<i>Rumex acetosella</i>	1	3	3.0	2.8	2	4	15.0	1	5	3.0
<i>Senecio jacobaea</i>	R	5	0.1							
<i>Sidalcea species</i>	R	5	0.1	0.9	2	5	15.0	1	5	3.0

Habitat restoration and monitoring for Kincaid's lupine (*Lupinus oreganus*) at Fir Butte: 2018 annual report

	Area C			Area D	E-north			E-south		
	Cover	Soc.	Midpt.	Avg. Cover	Cover	Soc.	Midpt.	Cover	Sociability	Midpoint
<i>Toxicodendron diversilobum</i>										
<i>Vicia hirsuta</i>				0.1	R	5	0.1	1	5	3.0
<i>Vicia sativa</i>	R	5	0.1	0.1	R	5	0.1	1	5	3.0
<i>Agrostis capillaris</i>	2	2	15.0	18.9	2	4	15.0	4	1	62.5
<i>Aira caryophyllea</i>	R	5	0.1	0.2						
<i>Anthoxanthum odoratum</i>	1	4	3.0	1.2						
<i>Arrhenatherum elatior</i>	R	4	0.1	1.5	R	5	0.1	R	5	0.1
<i>Avena fatua</i>										
<i>Bromus hordeaceus</i>				0.2	R	5	0.1	R	5	0.1
<i>Bromus rigidus</i>				0.3	R	5	0.1			
<i>Cynosurus echinatus</i>										
				0.5						
<i>Danthonia</i>										
<i>Festuca arundinacea</i>				2.5						
<i>Festuca roemerii</i>	1	4	3.0		2	4	15.0	1	5	3.0
<i>Holcus lanatus</i>	R	5	0.1		R	5	0.1			
<i>Luzula sp.</i>	+	5	0.7		R	4	0.1			
				0.4						
<i>Vulpia bromoides</i>	R	5	0.1	3.1				R	5	0.1
<i>Vulpia sp.</i>										
Forb Total			59.6	23.2			101.9			15.5
Native Forb			36.8	10.0			51.0			3.5
Introduced Forb			22.8	13.2			51.0			12.0
Graminoid Total			22.0	28.8			30.4			65.7
Native Graminoid			3.7	0.0			15.1			3.0
Introduced Graminoid			18.3	28.8			15.4			62.8
Tree/Shrub			0.7	9.1			3.0			0.7