Habitat restoration for Kincaid's Lupine (*Lupinus oreganus*) at Fir Butte: 2019 annual report

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

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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.

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1. EXECUTIVE SUMMARY

This report documents habitat restoration and monitoring work conducted in 2019 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 2019, 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, and providing follow-up treatments after a prescribed burn.

Due to lack of funding, no vegetative monitoring was conducted at Fir Butte in 2019.

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).

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

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 relatively stable or increasing, although there is some annual fluctuation (Appendix 5). 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.

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.

4. RESTORATION ACTIVITIES

4.1. 2019 overview

In 2019, 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, and providing follow-up treatments after a prescribed burn. Fender's blue butterfly data collection methodology and data are not reported here, but are submitted to the BLM in a separate document. Table 1 summarizes the restoration actions completed at Fir Butte in 2019. 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 2019.

Date	Action	Personnel*	Description
3/26, 3/29	Site preparation	IAE	Flagged lupine in SE corner (burn area)
4/16	Herbicide application	IAE/Contractor (IRM)	Broadcast glyphosate over 1.5 acres in SE corner; flagged lupine areas were not sprayed
4/23	Herbicide application	IAE/Contractor (IRM)	Broadcast glyphosate over additional 1.5 acres in SE corner; flagged lupine areas were not sprayed
5/14, 5/15, 5/22	Weed control	IAE	Mowed tall oatgrass and bracken fern
5/22	Weed control	IAE/Contractor (IRM)	Spot sprayed bracken fern with 1.5% solution of glyphosate
5/22	Weed control	IAE/Contractor (IRM)	Applied glyphosate with weed wiper on bracken fern
5/24	Weed control	IAE/BLM	Mowed tall oatgrass
6/11	Weed control	IAE	Spot sprayed meadow knapweed with 1.5% solution of glyphosate
7/24	Weed control	IAE	Hand pulled and spot sprayed meadow knapweed
7/20	Site preparation	IAE	Removed pin flags from SE corner to prepare for mowing
9/12	Weed control	IAE/Contractor (NTS)	Spot sprayed blackberry, hawthorn, and rose
11/5	Site preparation	BLM/Contractor (LGYC)	Removed weed cloth from nectar island 6d

*Institute for Applied Ecology (IAE); Bureau of Land Management (BLM); Looking Glass Youth Crew (LGYC); Nick's Timber Services (NTS); Integrated Resource Management (IRM)

4.2. Nectar islands

4.2.1. Nectar island history

The primary objective of nectar islands is 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. Preparation for establishing the first nectar islands at Fir Butte began in 2012 with installation of shadecloth over five 8m x 10m plots (the "a" series, plots 1a-5a; Figure 3, Appendix 3). The shadecloth was left in place for at least a year, and removed in 2013 (plots 2a, 3a, 4a) or 2014 (plots 1a and 5a). Nectar islands were seeded and/or plugs were planted with native species in either 2013 or 2014. Preparation for a second group of nectar islands (the "b" series, 1b-5b) was initiated in 2013/2014 with shadecloth installation. These plots were planted and/or seeded in 2014 (3b) or 2015 (1b, 2b, 4b, 5b). Four additional nectar island plots (the "c" series, 1c, 2c, 4c, 5c) had shadecloth installed in 2015, and were planted and/or seeded in 2016.

Unfortunately, since their creation the earlier nectar islands have been invaded by non-native grasses. In 2017, one new nectar island (6d) was established by installing plastic for a three-month solarization treatment, then removing the plastic and installing shadecloth. In order to reduce non-native grass cover, the shadecloth was left in place in this plot, and holes were burned into it and subsequently planted and/or seeded in the fall of 2017. A similar approach was taken with two of the three plots established in 2018 (4e[small] and 7e); plots had plastic installed for three months, then it was removed and seeded in the fall of that year (Giles et al. 2018).

In late fall 2018, herbicide became available as a weed control tool on BLM sites in West Eugene, and a new approach to nectar island establishment was initiated. In December of 2018, plot 4e(big) (larger of the two 4e plots, Figure 3) was sprayed with a broadcast application in preparation for future seeding and planting. Many of the nectar islands have received various additional weed control treatments (hand pulling, mowing, prescribed burn) and planting and overseeding since their establishment.

See Appendix 3 for a summary of nectar island establishment and treatments.

4.2.2. Nectar island management

In 2019, the shadecloth from plot 6d (which had had planting holes burned into it) was removed. With herbicide becoming available as a site preparation tool, there are no plans to establish new nectar plots using shadecloth or plastic solarization at this time.

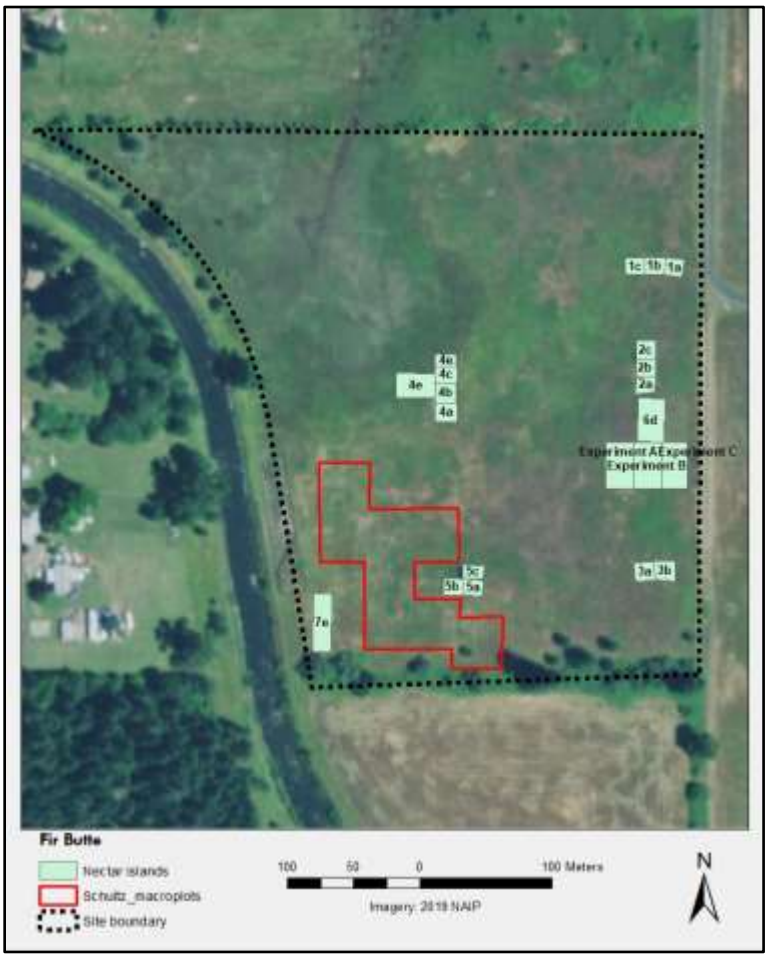

FIGURE 3. NECTAR ISLANDS AND EXPERIMENTAL PLOT LOCATIONS AT FIR BUTTE. PLOTS WITH AN 'A' WERE ESTABLISHED (SEEDED AND/OR PLANTED) IN 2013/2014, 'B' IN 2015, 'C' IN 2016, 'D' IN 2017 AND 'E' IN 2018.

4.3. Invasive species control

In 2019, invasive species management primarily targeted tall oatgrass, bracken fern, meadow knapweed (*Centaurea pratensis*) and woody species such as blackberry, hawthorn (*Crataegus monogyna*) and rose (*Rosa* spp.). IAE and BLM staff used string trimmers to mow tall oatgrass, IAE and contractors conducted spot-spray herbicide treatments targeting bracken fern, meadow knapweed, blackberry, hawthorn, and rose, and IAE and a contractor broadcast sprayed a 1.5-acre area in the SE corner that had been burned in the fall of 2018 (flagging and avoiding Kincaid's lupine).

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, Figure 4). The goal of mowing this species 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 5). In addition, the amount of staff time needed to mow tall oatgrass has nearly doubled; in 2018

and 2019 it took approximately 40 hours to mow the tall oatgrass using string trimers, whereas in earlier 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. A third option may be to broadcast spray tall oatgrass in the late fall/early winter after green-up when Kincaid's lupine is dormant. This last option would be most effective if implemented after a prescribed burn (preferred) or a fall mowing of the area to remove thatch.

FIGURE 4. TALL OATGRASS (*ANTHENATHERUM ELATIUS*) GROWING IN A KINCAID'S LUPINE (*LUPINUS OREGANUS*) PATCH (LEFT). KINCAID'S LUPINE PATCH AFTER TALL OATGRASS WAS MOWED (RIGHT)

FIGURE 5. TALL OATGRASS (*ANTHENATHERUM ELATIUS*) DISTRIBUTION (ORANGE) AT FIR BUTTE IN 2010 (TOP) AND 2018 (BOTTOM).

4.3.2. Bracken fern

Bracken fern, although native, is considered an invasive species of concern at Fir Butte. The population has increased over time, and due to its height and broad fronds, there is a concern that it will outcompete the Kincaid's lupine and other desirable native species, as well as impede access of Fender's blue butterflies to lupine and nectar resources.

In past years, bracken fern has been mowed and hand pulled. However, mowing alone is not enough 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 West Eugene Wetlands Biological Opinion (USFWS 2014) prohibits mowing Kincaid's lupine-occupied areas with a tractor during the Kincaid's lupine growing season, which limits the ability to control bracken fern in this manner.

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.

In 2019, with herbicide becoming available as a treatment tool, we targeted bracken fern with a two-pronged approach. In early and mid-May, bracken fern fronds were mowed at the same time as tall oatgrass. This treatment was followed by either a spot-spray application of glyphosate (primarily in areas where Kincaid's lupine was not nearby) or a weed wiper application of glyphosate (in the vicinity of Kincaid's lupine) on May 22nd.

4.3.3. 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. In past years, meadow knapweed stems were cut, bagged and removed from the site multiple times during the growing season in order to reduce seed set. Starting in December of 2018, we began targeting meadow knapweed individuals with spot-spray treatments of a 1.5% glyphosate solution (Figure 6).

FIGURE 6. MEADOW KNAPWEED (*CENTAUREA PRATENSIS*) IN EARLY JANUARY 2019 AFTER FIRST HERBICIDE TREATMENT WAS BEGINNING TO EFFECT PLANTS.

In 2019, IAE implemented several additional spot-spray treatments of meadow knapweed on 6/11 and 7/24. Meadow knapweed plants that were too close to Kincaid's lupine to target with herbicide were hand pulled.

One of the challenges controlling meadow knapweed at Fir Butte is that the primary seed source population is on private property to the north and east of BLM-owned land. The landowner to the north was contacted last year by IAE staff and showed interest in allowing a third party to manage the meadow knapweed. When staff from the USFWS's Partners for Fish and Wildlife Program followed up

with the owner, they were open to discussion, but stated that they would treat the meadow knapweed themselves. 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.

4.4. Post-burn chemical fallow

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 7 and Figure 8).

FIGURE 7. 2018 BURN UNIT LOCATION AT FIR BUTTE IN 2018 (CROSS-HATCHED AREAS). UNITS WERE BURNED ON 10/13/18.

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 PROJEXTS 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 8. 2018 PRESCRIBED BURN AT FIR BUTTE WAS EXECUTED FALL 2018. APPROXIMATELY FIVE ACRES OF THE SE CORNER (LEFT) AND NECTAR ISLANDS (RIGHT) WERE BURNED.

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. The first broadcast herbicide treatment was applied on December 7, 2018, once vegetation began greening up after the prescribed burn. The primary species targeted were non-native grasses.

In March of 2019, any emerging Kincaid's lupine individuals within the burned area were flagged, and in April a second broadcast treatment of glyphosate was applied over ~1.5 acres within the southeast corner, avoiding flagged lupine areas (Figure 9). In May, meadow knapweed was targeted for spot-spray treatments throughout the site, including within the SE burned area.

FIGURE 9. INTEGRATED RESOURCE MANAGEMENT STAFF APPLYING A BROADCAST TREATMENT OF GLYPHOSATE ON UNOCCUPIED AREAS WITHIN THE BURNED AREA IN APRIL 2019.

The intention was to implement another broadcast herbicide application within the chemical fallow area in December of 2019, during the period when Kincaid's lupine was dormant. Implementing a broadcast spray during the winter is important to treat weeds located within the lupine patches, since it is challenging to treat them when the lupine is present. However, around that time BLM staff discovered that neighboring cattle had broken into the site in the late fall, and concerns about the impacts of the cattle on the habitat caused a delay in the treatment. By the time the matter was resolved later in the

winter, the Kincaid's lupine plants had already begun to emerge. We will continue to implement spot spray treatments within the lupine-occupied portions of the chemical fallow area in 2020.

4.5. Grass-specific herbicide experiment

In previous years, IAE worked with the BLM and Dr. Cheryl Schultz of Washington State University to implement a study assessing the effects of a grass-specific herbicide on Fender's blue butterfly, Kincaid's lupine and the vegetative community. The treatments were completed in 2018. See Binnion et al. 2020 for more information about the results of this study.

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. In 2019, no Kincaid's lupine or vegetation monitoring was conducted due to lack of funding. Please see Appendix 5 for a summary of Kincaid's lupine monitoring results from 1998-2018, and Giles et al. 2019 for a more complete description of monitoring methodology and results.

6. 2020 PROPOSED ACTIONS

In 2020, IAE proposes that the following habitat restoration and assessment activities are implemented:

- Continue targeted herbicide applications of meadow knapweed, bracken fern, blackberry, and other high priority species throughout the site.
- 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.
- Monitor the Kincaid's lupine population and overall site habitat quality through the collection of plant community data.
- Work with BLM staff to identify areas along the property boundary vulnerable to potential incursions from neighboring cattle and develop plan to prevent such incursions.
- Continue to develop relationship with neighboring landowners. Work with BLM and/or USFWS to coordinate treatment of meadow knapweed on neighboring properties, where feasible.

- Hold biannual IAE-BLM meetings to coordinate restoration treatments at Fir Butte.
- Write annual report.

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8. APPENDICES

Appendix 1. Fir Butte management actions (2008-2019)

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	June-July	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	BLM	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	BLM	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	BLM contractor	
2011	August-October	Prescribed burn	BLM	NE third of upland
2011	August-October	Seed nectar mix	BLM	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
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	BLM	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
2013	17-Apr	Marking of weeds site wide	IAE	Systematically began wandering through site and marking locations of *Cirsium vulgare*, *Cytisus scoparius*, *Centaurea x pratensis*, *Lepidium heterophyllum*, *Hypericum perforatum*, and *Senecio jacobaea*.
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	Mow tall oatgrass with string trimmer, hand weeding solarization plots	IAE, NWYC crew of 6	Mow 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 mowing small patches. Did not mow 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 going…attempted to be thorough but realized by end of the day that it is impractical with this density of *Agrostis capillaris* and *Rumex acetosella* 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 *Lepidium heterophyllum* 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 Appendices 1 and 3 for planting summary for details,

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 *Lupinus oreganus*, mowed above top of raceme. At Cheryl Schultz' request did not finish L shape patch in SW corner.
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 *Lupinus oreganus*
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	Removed 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 1a, 5a. Did not reflame 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, Lepidium, thistle, tansy ragwort in northern portion of site
2015	6-May	Remove weeds	IAE	Removed meadow knapweed rosettes, Lepidium, thistle, tansy ragwort throughout site
2015	12-May	Monitoring	IAE	Collected data from shadecloth/solarization test plots
2015	13-May	Removed weeds	IAE	Removed Lepidium 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. Where growing concurrently with *Lupinus oreganus*, 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 *agrostis* 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 (*Centaurea pratensis*), Purpleanther field pepper weed (*Lepidium heterophyllum*), bull thistle (*Cirsium vulgare*), tansy ragwort (*Senecio jacobea*) in northern portion of site; removed hairy cat's ear (*Hypochaeris* spp.), sheep sorrel (*Rumex acetosella*), and bentgrasses (*agrostis* 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 (*Rubus armeniacus*) 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 *Fragaria virginiana* runners
2017	15-Nov	Planting	IAE, BLM and Looking Glass	Planted approximately 1600 *Triteleia hyacinthine* bulbs
2017	20-Nov	Planting	IAE	Planted 50 pots of *Eriophyllum lanatum* and *Sidalcea malviflora*, 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 *Eriophyllum lanatum*, 300 *Sidalcea malviflora* pots, ~300 *Camassia leichtlinii* and ~300 *Allium amplectens* 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.
2019	3/26, 3/29	Site preparation	IAE	Flagged lupine in SE corner (burn area)
2019	4/16	Herbicide application	IAE/Contractor (IRM)	Broadcast glyphosate over 1.5 acres in SE corner; flagged lupine areas were not sprayed
2019	4/23	Herbicide application	IAE/Contractor (IRM)	Broadcast glyphosate over additional 1.5 acres in SE corner; flagged lupine areas were not sprayed
2019	5/14, 5/15, 5/22	Weed control	IAE	Mowed tall oatgrass and bracken fern
2019	5/22	Weed control	IAE/Contractor (IRM)	Spot sprayed bracken fern with 1.5% solution of glyphosate
2019	5/22	Weed control	IAE/Contractor (IRM)	Applied glyphosate with weed wiper on bracken fern

Year	Date	Activity	Personnel*	Notes
2019	5/24	Weed control	IAE/BLM	Mowed tall oatgrass
2019	6/11	Weed control	IAE	Spot sprayed meadow knapweed with 1.5% solution of glyphosate
2019	7/24	Weed control	IAE	Hand pulled and spot sprayed meadow knapweed
2019	7/20	Site preparation	IAE	Removed pin flags from SE corner to prepare for mowing
2019	9/12	Weed control	IAE/Contractor (NTS)	Spot sprayed blackberry, hawthorn, and rose
2019	11/5	Site preparation	BLM/Contractor (LGYC)	Removed weed cloth from nectar island 6d

* BLM (Bureau of Land Management), IAE (Institute for Applied Ecology), IRM (Integrated Resource Management), LGYC (Looking Glass Youth Crew), NTS (Nick's Timber Service), NWYC (Northwest Youth Crew)

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

Appendix 3. Nectar island establishment history

Plot	Size	Year established (shadecloth)	Year planted
1a	8m x 10m	2012	2014 (plants), 2015 (seed), 2016 (seed)
1b	8m x 10m	2014	2015 (seed), 2016 (seed)
1c	8m x 10m	2015	2016 (plants and seed)
2a	8m x 10m	2012	2013 (plants and seed), 2016 (seed)
2b	8m x 10m	2013	2015 (plants and seed) 2016 (seed)
2c	8m x 10m	2015	2016 (plants and seed)
3a	8m x 10m	2012	2013 (plants and seed), 2016 (seed)
3b	8m x 10m	2013	2014 (plants), 2015 (seed), 2016 (seed)
4a	8m x 10m	2012	2014 (plants), 2015 (seed), 2016 (seed)
4b	8m x 10m	2013	2015 (plants and seed), 2016 (seed)
4c	8m x 10m	2015	2016 (plants and seed)
5a	8m x 10m	2012	2014 (plants and seed), 2016 (seed)
5b	8m x 10m	2014	2015 (plants and seed), 2016 (seed)
5c	8m x 10m	2015	2016 (plants and seed)
6d	15m x 25m	2017	2017 (plants and seed)
4e(small)	9m x 8m	2018	2018 (seed)
7e	6m x 20m	2018	2018 (seed)
4e(big)	20m x 13m	2018* (glyphosate)	Not yet

*Starting in 2018, herbicides became available as a site preparation tool, and a glyphosate treatment (instead of shadecloth) was used to prepare Plot 4e(big).

Appendix 4. Plant materials added to nectar islands between 2014-2018

2014 plants added to nectar islands

Species		Form	Number of plants		
Scientific name	Common name		Plot 1a	Plot 3b	Plot 5a
Eriophyllum lanatum	Oregon sunshine	1'x2' Flats	62	62	62
Sidalcea malviflora spp. *virgata*	dwarf checkermallow	Heritage medium plug trays	440	320	320
Lomatium nudicaule	barestem biscuitroot	Bare root	233	233	233
Allium amplectens	narrowleaf onion	Bare root bulbs	550	550	550
Festuca roemeri	Roemer's fescue	Heritage medium plug trays	160	320	320
Luzula comosa	Pacific woodrush	Heritage medium plug trays	91	91	91
Camassia leichtlinii	large camas	Bulbs in 1'x2' flats	3 trays	3 trays	4 trays
Zigadenus venenosus	death camas	Bulbs in 1'x2' flats	3 trays	2 trays	3 trays
Triteleia hyacinthina	white brodiaea	Bulbs in 1'x2' flats		1 tray	

2014 seed added to nectar islands

Species		Total seed (lbs) in plots 1a, 3b and 5a combined
Scientific name	Common name	
Achillea millefolium	common yarrow	0.06
Camassia leichtlinii	large camas	1.31
Clarkia purpurea ssp. *quadrivulnera*	farewell-to-spring	0.02
Epilobium densiflorum	denseflower willowherb	0.05
Eriophyllum lanatum	Oregon sunshine	0.07
Festuca roemeri	Roemer's fescue	0.35
Linanthus bicolor	true babystars	0.02
Luzula comosa	Pacific woodrush	0.09
Microseris laciniata	cutleaf silverpuffs	0.10
Plectritis congesta	shortspur seablush	0.07
Potentilla gracilis	slender cinquefoil	0.03
Prunella vulgaris var. lanceolata	lance selfheal	0.16
Sidalcea malviflora ssp. *virgata*	dwarf checkermallow	0.49
Wyethia angustifolia	narrowleaf mule's ears	0.66
Total		**3.49**

2015 plants added to nectar islands

Species		Form	Number of plants			
Scientific name	**Common name**		**Plot 1b**	**Plot 2b**	**Plot 4b**	**Plot 5b**
Iris tenax	Oregon iris	4" pots	10	10	10	10
Sisyrinchium idahoense	Idaho blue-eyed grass	4" pots	20	20	20	20
Eriophyllum lanatum	Oregon sunshine	Small band pots	15	15	15	15
Sidalcea malviflora spp. *virgata*	dwarf checkermallow	Heritage medium plug trays	640	640	640	640
Allium amplectens	narrowleaf onion	Bulbs in 1' x 2' flats (100 bulbs per flat)	1.75 trays	1.75 trays	1.75 trays	1.75 trays
Festuca roemeri	Roemer's fescue	Heritage medium plug trays	612	612	612	612
Zigadenus venenosus	death camas	Bulbs in 1'x2' flats (100 bulbs per flat)	1.25 trays	1.25 trays	1.25 trays	1.25 trays
Fragaria virginiana	wild strawberry	Ramets	250	250	250	250

2015 plants added to nectar islands

Species seeded		Total seed (lbs) in plots 1b, 2b, 4b and 5b combined
Scientific name	**Common name**	
Achillea millefolium	common yarrow	0.09
Camassia leichtlinii	large camas	1.61
Clarkia purpurea ssp. *quadrivulnera*	farewell-to-spring	0.02
Epilobium densiflorum	denseflower willowherb	0.07
Eriophyllum lanatum	Oregon sunshine	0.23
Festuca roemeri	Roemer's fescue	0.52
Linanthus bicolor	true babystars	0.02
Lomatium nudicaule	barestem biscuitroot	0.22
Microseris laciniata	cutleaf silverpuffs	0.12
Nemophila menziesii var. *atomaria*	baby blue eyes	0.06
Plectritis congesta	shortspur seablush	0.51
Potentilla gracilis	slender cinquefoil	0.40
Prunella vulgaris var. *lanceolata*	lance selfheal	0.18
Sidalcea malaviflora ssp. *virgata*	dwarf checkermallow	0.83
Wyethia angustifolia	narrowleaf mule's ears	0.75
Total seed (lbs)		**5.22**
Total forb seed (lbs)		**4.7**
Total graminoid seed (lbs)		**0.52**

2016 plants added to nectar islands

Species planted		Form	Number of plants			
Scientific name	**Common name**		**Plot 1c**	**Plot 2c**	**Plot 4c**	**Plot 5c**
Sidalcea malviflora spp. *virgata*	dwarf checkermallow	Medium plugs	400	400	400	400
Allium amplectens	narrowleaf onion	Bulbs	375	375	375	375
Festuca roemeri	Roemer's fescue	Medium plugs	100	100	100	100
Luzula comosa	Pacific woodrush	Medium plugs	200	200	200	200
Lomatium nudicaule	barestem biscuitroot	Bareroot stems	800	800	500	500
Total number of plants			**1875**	**1875**	**1575**	**1575**

2016 seed added to nectar islands

Species seeded		Total seed (lbs)*
Scientific name	**Common name**	
Achillea millefolium	common yarrow	0.20
Camassia leichtlinii	large camas	1.59
Clarkia purpurea	farewell-to-spring	0.06
Epilobium densiflorum	denseflower willowherb	0.09
Eriophyllum lanatum	Oregon sunshine	0.17
Festuca roemeri	Roemer's fescue	0.84
Linanthus bicolor	true babystars	0.02
Lomatium nudicaule	barestem biscuitroot	0.19
Microseris laciniata	cutleaf silverpuffs	0.17
Nemophila menziesii var. *atomaria*	baby blue eyes	0.05
Plectritis congesta	shortspur seablush	0.21
Potentilla gracilis	slender cinquefoil	0.07
Prunella vulgaris var. *lanceolata*	lance selfheal	0.31
Sidalcea malviflora spp. *virgata*	dwarf checkermallow	0.83
Wyethia angustifolia	narrowleaf mule's ears	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 plants added to nectar plot 6d

Species		Quantity
Scientific name	**Common name**	
Allium amplectens	narrowleaf onion	Approximately 300 plugs
Camassia leichtlinii	large camas	Approximately 300 plugs
Eriophyllum lanatum	Oregon sunshine	250 band pots
Sidalcea malviflora ssp. *virgata*	dwarf checkermallow	350 band pots

2017 seed added to nectar plot 6d

Species		Total seed (lbs/acre)
Scientific name	**Scientific name**	
Achillea millefolium	common yarrow	0.2
Camassia leichtlinii var. *suksdorfii*	large camas	1.59
Clarkia purpurea	purple clarkia	0.06
Epilobium densiflorum	denseflower willowherb	0.09
Eriophyllum lanatum \	Oregon sunshine	0.17
Festuca roemeri	Roemer's fescue	0.84
Linanthus bicolor	true babystar	0.02
Lomatium nudicaule	barestem biscuitroot	0.2
Microseris laciniata	cutleaf silverpuffs	0.17
Nemophila menziesii var. *atomaria*	baby blue eyes	0.11
Plectritis congesta	shortspur seablush	0.21
Potentilla gracilis var. *gracilis*	slender cinquefoil	0.07
Prunella vulgaris var. *lanceolata*	lance selfheal	0.31
Sidalcea malviflora ssp. *virgata*	dwarf checkermallow	0.83
Wyethia angustifolia	narrowleaf mule's ears	0.48
Total		**5.35**

* Approximately two tbsp/hole of seed mix was put in unoccupied holes in the weed barrier.

2018 seed added to nectar plots

Species		Total seed (lbs/acre)
Scientific name	**Common name**	
Achillea millefolium	common yarrow	0.1
Allium amplectens	narrowleaf onion	1.2
Camassia leichtlinii	large camas	5.01
Eriophyllum lanatum	Oregon sunshine	0.81
Lomatium nudicaule	barestem biscuitroot	1.21
Luzula comosa	Pacific woodrush	0.12
Microseris laciniata	cutleaf silverpuffs	0.29
Plectritis congesta	shortspur seablush	0.2
Prunella vulgaris	self-heal	0.34
Ranunculus occidentalis	Western buttercup	0.44
Sidalcea malviflora	dwarf checkermallow	4
Sisyrinchium idahoense	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 (4e Small and 7e).

Appendix 5. Foliar cover, number of leaves, number of mature racemes, and racemes/m² of Kincaid's lupine at Fir Butte from 1998-2018*.

Year	Estimated # of leaves		Estimated foliar cover (m²)		Estimated # of mature racemes		Estimated # racemes/m²
	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
2019	-	-	-	-	-	-	-

* Kincaid's lupine was not monitored in 2019.