Habitat restoration and monitoring for Kincaid's lupine at Fir Butte: 2023 annual report

February 2024

Report for the Bureau of Land Management, Northwest Oregon District, Agreements #L20AC00014, #L21AC10189, and #L22AC00362

Report prepared by Paul Reed, Denise Giles, Andrew Esterson, and Scott Harris

Institute for Applied Ecology

Institute for Applied Ecology

PREFACE

IAE is a non-profit organization whose mission is the 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.

Questions regarding this report or IAE should be directed to:

Thomas Kaye (Executive Director)
Institute for Applied Ecology
4950 SW Hout St.
Corvallis, OR 97333

phone: 541-753-3099
fax: 541-753-3098
email: info@appliedeco.org

ACKNOWLEDGEMENTS

Funding for this project was provided by the Bureau of Land Management (BLM), Assistance Agreements #L20AC00014, #L21AC10189, and #L22AC00362. We thank Sally Villegas-Moore of the BLM for her guidance and for sharing her knowledge of the site. We also thank Colin Sayre and Christine Calhoun of the BLM for their support with habitat management actions, as well as the Lane-Metro Youth Corps for their weed pulling efforts. We are grateful to the City of Eugene for donating dwarf checkermallow (*Sidalcea malviflora ssp. virgata*) plants in 2023 and to our many volunteers, partners, and seasonal staff for their contributions over the life of this project.

Cover photograph: Kincaid's lupine (*Lupinus oreganus*) in full bloom on May 19, 2023, following a prescribed burn the previous fall. *Photo by Paul Reed.*

SUGGESTED CITATION

Reed, P., D. Giles, A. Esterson, and S. Harris. 2024. Habitat restoration and monitoring for Kincaid's lupine at Fir Butte: 2023 annual report. Prepared by the Institute for Applied Ecology for the Bureau of Land Management, Northwest Oregon District. Corvallis, Oregon.

TABLE OF CONTENTS

Habitat restoration and monitoring for Kincaid's lupine at Fir Butte: 2023 annual report

EXECUTIVE SUMMARY

This report documents habitat restoration and monitoring work conducted in 2023 by the Institute for Applied Ecology (IAE) at Fir Butte, an 18-acre site located west of Eugene, Oregon that is owned and managed by the Bureau of Land Management, Northwest Oregon District (BLM). Fir Butte hosts large populations of the federally threatened Fender's blue butterfly (*Icaricia icarioides fenderi*) and its host plant, the federally threatened Kincaid's lupine (*Lupinus oreganus*).

The BLM has been partnering with IAE for over two decades to monitor Kincaid's lupine and the plant community at Fir Butte. Since 2012, IAE has also been conducting habitat restoration activities with the aim of conserving and bolstering populations of the lupine and butterfly. Restoration has been primarily focused in the three upland areas of the site: the northeast (NE), southeast (SE), and southwest (SW) sections. Herbicide use was first permitted in 2018 and most herbicide treatments since then have occurred in the NE and SE sections.

In 2023, IAE planned and implemented a variety of activities to support Kincaid's lupine and Fender's blue butterfly at Fir Butte. These activities included weed control treatments, planting Fender's blue butterfly nectar species, seeding native prairie species, and monitoring.

2023 monitoring results indicate that:

- Kincaid's lupine foliar cover and count of racemes remained stable from 2022 to 2023 with an estimated 6,701m^2 (±2,739) of Kincaid's lupine cover and 148,133 (±60,301) mature racemes.
- The average Himalayan blackberry (*Rubus bifrons*) cover continued to be low at just 1.2% (±1.2%) across the site in 2023. This is well under the 5% threshold recommended for weed species of concern in the Recovery Plan for the Prairie Species of Western Oregon and Southwestern Washington (U.S. Fish and Wildlife Service 2010). This is the fourth consecutive year that blackberry cover has been below this threshold.
- The cover of introduced graminoids was highest in the unburned and minimally treated SW section of the site with more than 50% absolute cover (77% relative cover).
- The NE section, which burned in fall 2022, had nearly 40% bare ground cover following the burn. The dominant functional group in this section was native forbs, largely driven by Kincaid's lupine.
- In the SE section, the absolute cover of introduced graminoids and forbs decreased in 2023, but these two functional groups remain dominant in this section (combined 85% relative cover).
- Since 2018, Kincaid's lupine cover has increased more in the NE and SE sections compared to the SW section.

1. INTRODUCTION

1.1. Site background

Fir Butte is an 18-acre site owned and managed by the Bureau of Land Management (BLM), Northwest Oregon District, and is 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, and it supports large populations of the federally threatened Fender's blue butterfly (*Icaricia icarioides fenderi*) and the federally threatened Kincaid's lupine (*Lupinus oreganus*; Figure 1). Other Bureau-sensitive species, including white-topped aster (*Sericocarpus rigidus*) and three rare bryophyte species (*Bruchia flexuosa*, *Ephemerum crassinervium*, and *Ephemerum serratum*), 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 (hereafter the "Recovery Plan") (U.S. Fish and Wildlife Service 2010).

Figure 1. Fender's blue butterfly (*Icaricia icarioides fenderi*; left) and Kincaid's lupine (*Lupinus oreganus*; right).

Prior to acquisition 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 was poor at the time of acquisition, with heavy infestations of introduced plants such as tall oatgrass (*Arrhenatherum elatius*), annual grasses, and Himalayan blackberry (*Rubus bifrons*).

The BLM began partnering with the Institute for Applied Ecology (IAE) in the early 2000s to monitor the Kincaid's lupine population at Fir Butte. IAE then began to perform habitat restoration actions at the site in 2012. Since IAE initiated restoration activities, the Fender's blue butterfly population has remained relatively stable or increased, with annual fluctuations (Diaz and Harris 2024), while the Kincaid's lupine population has steadily increased (see Section 4.2.1 below). In general, restoration activities conducted by IAE have improved habitat conditions at Fir Butte. While the site does not yet meet all habitat quality and population benchmarks for listed species as identified in the Recovery Plan (U.S. Fish and Wildlife Service 2010), conditions at this site have been moving in the right direction. Future management actions,

including weed control, prescribing burning, seeding, augmentation, and introduction efforts, will help keep recovery goals on track.

1.2. Species background

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

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 May and June. After eggs hatch a few weeks later, larvae feed on Kincaid's lupine leaves until the plants begin to senesce in early July. After feeding, the larvae enter diapause and overwinter in the soil near the base of plants. During the following spring, larvae emerge from diapause and begin feeding on young Kincaid's lupine leaves and inflorescences before pupating for several weeks and emerging as butterflies to restart the cycle.

2. GOALS AND OBJECTIVES

The goal of this project is to improve habitat conditions at Fir Butte such that its populations of Kincaid's lupine and Fender's blue butterfly contribute to USFWS delisting objectives. We aim to do this by decreasing the abundance of non-native species and increasing the abundance and diversity of native species.

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

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

Specific monitoring goals include:

- Determine the abundance of Kincaid's lupine and summarize long term population trends.
- Summarize plant community composition to assess whether habitat quality thresholds for recovery are met.
- Obtain pre- and post-treatment data for prescribed fire and herbicide treatments.

This report summarizes the restoration and monitoring activities at Fir Butte in 2023.

3. 2023 RESTORATION ACTIVITIES

3.1. Overview

IAE implemented a variety of restoration activities at Fir Butte in 2023. A major focus for the year was to control problematic weeds across the northeast (NE) section of the site, following the prescribed burn that occurred in this management unit in fall 2022. The burn removed thatch and created bare ground, providing a great opportunity to treat weeds like tall oatgrass as they emerged. Additionally, we aggressively treated patches of false dandelion (*Hypochaeris radicata*) and non-native annual grasses (particularly rattail fescue (*Vulpia myuros*)) across the eastern half of the site, especially in the southeast (SE) management unit. These weeds have come to dominate much of the SE section following several years of limited chemical fallow treatments and a relatively unsuccessful seeding effort in 2021. We implemented weed treatments in 2023 using integrated pest management strategies with different methods of chemical and manual removal as described in section 3.2.

Another focus in 2023 was to boost native plant diversity and abundance, particularly for Fender's blue butterfly nectar species which have been relatively limited at Fir Butte aside from Kincaid's lupine and dwarf checkermallow (*Sidalcea malviflora ssp. virgata*). We capitalized on bare ground created by weed treatments and the 2022 prescribed burn to seed a total of 107 lbs of native prairie species across seven acres, as described in section 3.3. Additionally, we planted thousands of Fender's blue butterfly nectar plants from seven different species, as described in section 3.4.

Figure 2 is a map of the site which provides context on the management units described above. It also shows the extent of the Kincaid's lupine population (as of 2019) and a selection of 2023 restoration activities including herbicide weed wiping, hand pulling and cutting, and Fender's blue butterfly nectar planting areas. Table 1 summarizes all restoration actions completed at Fir Butte in 2023. See Appendix 1 for a summary of all management actions completed between 2008 to 2023, Appendix 2 for an annual update of photopoint images, Appendix 3 for a map of the site's prescribed burn history between 2008-2022, and Appendix 4-6 for details on nectar island plot units including a map, historical treatments, and plant material additions.

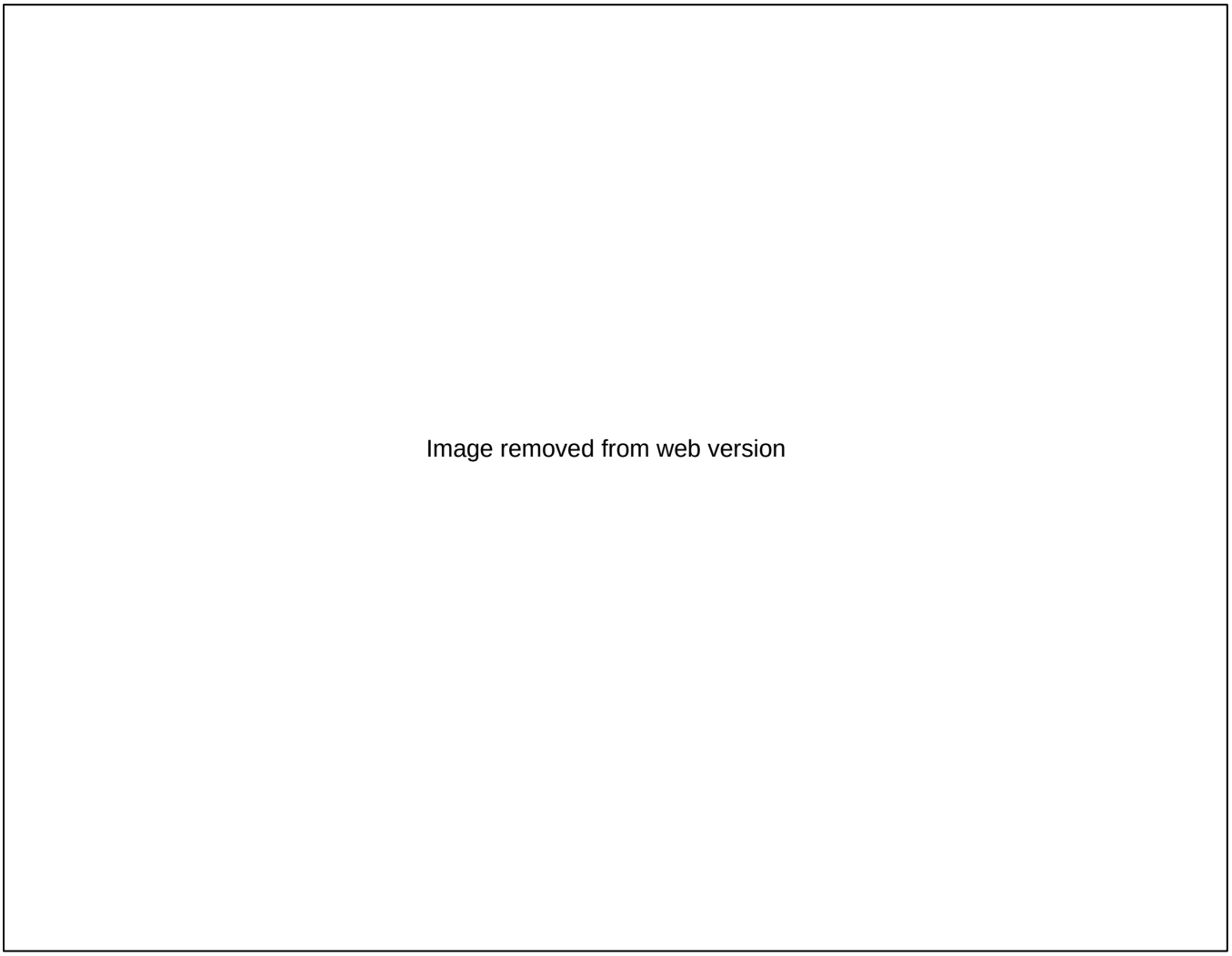


Figure 2. Map of Fir Butte divided into four management units: the northwest (NW), northeast (NE), southeast (SE), and southwest (SW) sections. Kincaid's lupine (*Lupinus oreganus*) distribution is shown as of the last mapping effort in 2019, which is still mostly accurate today. The NW section is wet prairie habitat and is therefore not suitable for Kincaid's lupine. Select 2023 restoration activities including herbicide weed wiping, major hand pulling/cutting efforts, and Fender's blue butterfly nectar planting locations are labeled with dates of occurrence (month/day; see Table 1).

Table 1. Management actions completed at Fir Butte in 2023.

Date	Action	Personnel*	Description
1/11/2023	Site visit	IAE	Site visit to assess efficacy of November 2022 post-burn broadcast herbicide treatment in NE section.
3/5/2023	Site visit	IAE	Site visit to assess spot spray treatment needs.
3/14/2023	Site visit	IAE, BLM	Site visit to discuss spot spray plans targeting tall oatgrass and false dandelion.

Date	Action	Personnel*	Description
3/16/2023	Weed control	IAE	Spot sprayed tall oatgrass, false dandelion, and rattail fescue across NE section with glyphosate. Used plant shields to protect Kincaid's lupine.
3/23/2023	Planting	BLM, Youth Corps	Planted ~300 dwarf checkermallow in NE section.
3/29/2023	Planting	IAE	Planted ~400 dwarf checkermallow in NE section.
4/27/2023	Weed control	IAE	Spot sprayed large patches of false dandelion and rattail fescue with glyphosate in SE section. Used weed dabber to wipe false dandelion where Kincaid's lupine seedlings were nearby.
5/9/2023	Site visit	IAE	Checked efficacy of 4/27 spot spray and weed dabbing treatments. Spot spray was effective, but weed dabber may not have coated false dandelion with enough herbicide to fully kill.
5/19/2023	Photopoints	IAE	Photopoints. Kincaid's lupine reaching peak bloom.
6/9/2023	Weed control	IAE	Hand wiped several patches of tall oatgrass with glyphosate amid Kincaid's lupine in NE section. Spot sprayed false dandelion and meadow knapweed across site with glyphosate. Hand pulled Queen Anne's lace in SE section.
6/15/2023	Weed mapping, weed control	IAE	Mapped tall oatgrass population and formulated plans for long-term control methods. Cut false dandelion heads in SE section and hand pulled dense patch of wild oat (*Avena fatua*) in NE section.
6/27-7/7/23	Monitoring	IAE	Monitoring of plant community, Kincaid's lupine cover, and target woody species.
7/13/2023	Weed control	IAE, BLM, Youth Corps	Hand pulled Queen Anne's lace from SE section. Hand pulled meadow knapweed across site.
7/26/2023	Site visit	IAE	Site visit to assess woody spot spray needs.
8/29/2023	Weed control	Contractor (R. Franco Restoration)	Spot sprayed Himalayan blackberry and other woodies across entire site.
9/20/2023	Site maintenance	BLM Contractor	Mowed eastern 10 acres of site. Western eight acres not mowed because it was originally on the 2023 burn plan.
10/3/2023	Weed control	IAE	Spot sprayed false dandelion patch in SE section, false dandelion, non-native perennial grasses, and rattail fescue throughout NE section, and meadow knapweed across site with glyphosate.
10/6/2023	Seeding	IAE	Seeded NE section (six acres) and portions of SE section (~one acre) with 77 lbs native prairie mix.

Date	Action	Personnel*	Description
			Marked areas in NE section with dense annual grass patches to treat and seed heavily.
10/13/2023	Weed control, seeding	IAE	Spot sprayed dense patches of annual grasses in NE section with glyphosate and seeded overtop with 30 lbs native prairie mix. Spot sprayed perennial grasses and meadow knapweed across site.
11/10/2023	Planting	IAE, volunteers	Planted thousands of Fender's blue butterfly native nectar plants across site.
12/15/2023	Site visit	IAE	Checked on plantings and formulated plans for early 2024 treatments.

*Institute for Applied Ecology (IAE); Bureau of Land Management (BLM).

3.2. Invasive species control

In 2023, IAE focused invasive species management efforts on non-native perennial grasses (particularly tall oatgrass), false dandelion, non-native annual grasses (such as rattail fescue), woody species (particularly Himalayan blackberry), and meadow knapweed. Other common weeds across the site include Queen Anne's lace (*Daucus carota*) and bracken fern (*Pteridium aquilinum*). To control weeds at various stages across the growing season, we used integrated pest management approaches including broadcast and spot spray herbicide applications, sponge dabber and hand wiping herbicide applications, hand pulling, grubbing, and seed-head cutting techniques.

Considering the widespread abundance of Kincaid's lupine and Fender's blue butterfly at Fir Butte, the timing and methods of weed control treatments are complicated by the need to avoid inadvertently harming these two species. As a result, IAE adheres to best practices as outlined in the 2015 PROJECTS Biological Opinion for the USFWS Region 1 (U.S. Fish & Wildlife Service 2015). When weed conditions warrant special consideration, IAE requests approval from the Kincaid's lupine and Fender's blue butterfly leads at the USFWS and BLM staff before enacting treatments that deviate from the Biological Opinion.

3.2.1. Tall oatgrass

Tall oatgrass is a non-native perennial bunchgrass that strongly outcompetes native vegetation such as Kincaid's lupine (Figure 3). Its tall stature (reaching >1.5m) and thick basal vegetation may be problematic for Fender's blue butterfly when trying to navigate between Kincaid's lupine and native nectar plants. Previously at Fir Butte (between 2013-2019), tall oatgrass was regularly mowed to approximately waist-height with a string trimmer in May or June. However, mowing was not an effective control method at this site as the population expanded during that time, especially across the NE section. An alternative approach may be to broadcast or spot spray tall oatgrass in the late fall or winter after green-up, when Kincaid's lupine is dormant. This may be most effective after a prescribed burn or mowing to remove thatch, since it would allow more herbicide to contact newly emerging tall oatgrass vegetation.

Figure 3. Tall oatgrass (*Arrhenatherum elatius*) growing tall and outcompeting Kincaid's lupine (*Lupinus oreganus*) at Fir Butte on May 19, 2023. Kincaid's lupine leaves are marked with a purple arrow and Kincaid's lupine flowering stalks marked with a blue arrow to emphasize how much tall oatgrass can smother its competition.

In November 2022, IAE contracted Habitat Restoration, LLC to broadcast glyphosate across the NE section management unit, about one month after a prescribed burn and within a few weeks of the tall oatgrass and other non-native grasses emerging (Reed et al. 2023). That treatment set back the first flush of grass considerably, giving the Kincaid's lupine an advantage when emerging in February 2023 (Figure 4). On March 16, 2023, IAE completed a spot spray across the NE section using glyphosate to target clumps of tall oatgrass and other weeds that began greening again, using plant shields to protect the emerging Kincaid's lupine.

Figure 4. (Left): Clumps of tall oatgrass (*Arrhenatherum elatius*) on January 11, 2023, that were set back due to a broadcast glyphosate application in November 2022. (Right): Kincaid's lupine (*Lupinus oreganus*) emerging on March 5, 2023, among clumps of senesced tall oatgrass and other non-native species.

By June 2023, it became clear that the fall broadcast and early spring spot spray made a considerable impact at reducing the tall oatgrass population across the NE section. IAE mapped the population on June 15 and found its distribution in the NE section to be approximately 75% of its 2021 extent (Figure 5). In the SW and SE sections however, where we did not target tall oatgrass for treatments, the population appears to have remained stable or even expanded somewhat.

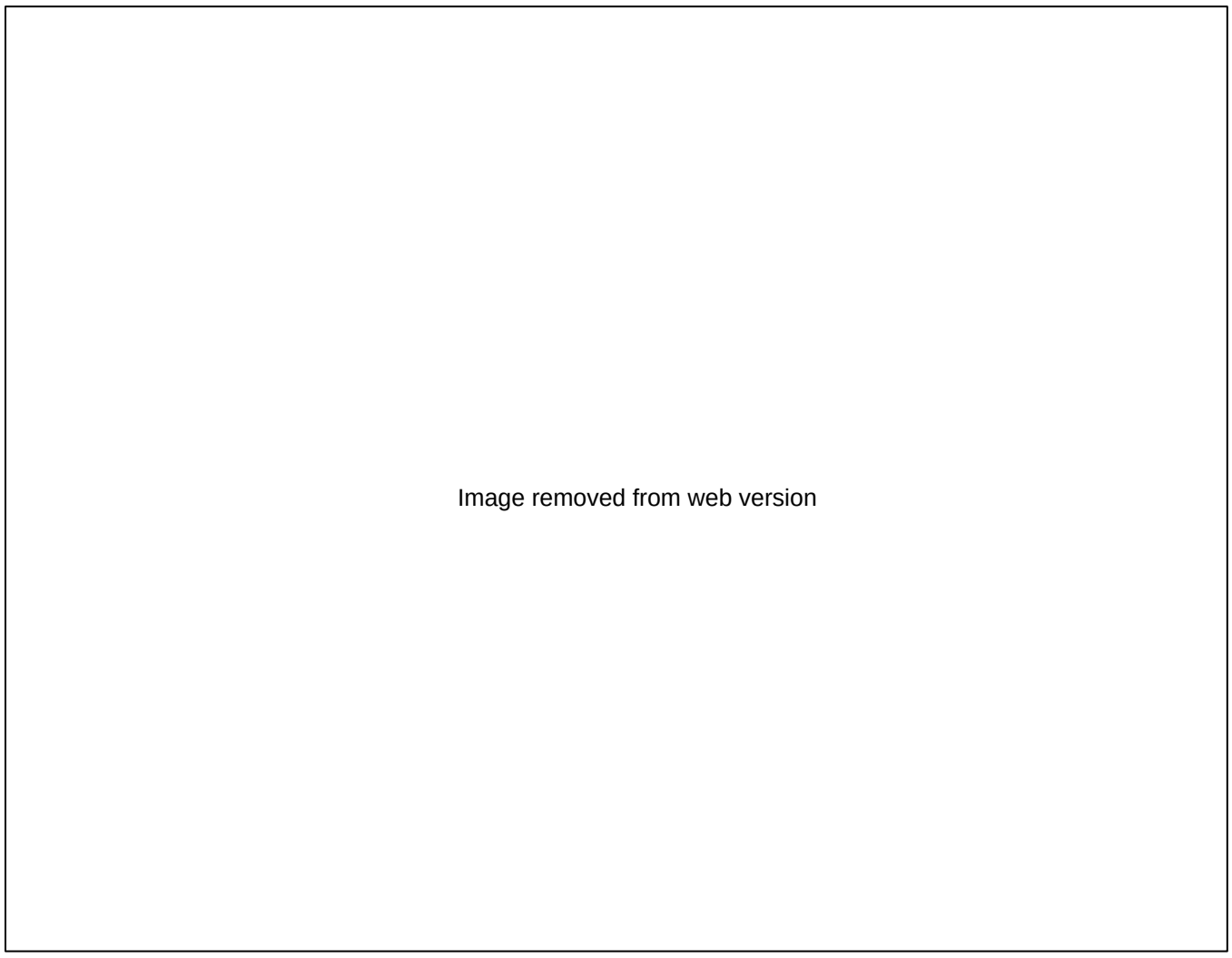


Figure 5. Tall oatgrass (*Arrhenatherum elatius*) distribution mapped at Fir Butte in 2023 and 2021. The tall oatgrass layers on the map are semi-transparent to visualize where the 2023 and 2021 distributions overlap.

Once the Kincaid's lupine and Fender's blue butterfly emerge (generally April through June), spraying herbicide becomes limited unless circumstances warrant special consideration for variances from the USFWS. An alternative to spraying during Fender's blue butterfly flight season that is approved in the PROJECTS Biological Opinion is weed wiping (U.S. Fish & Wildlife Service 2015). This method involves using a sponge or other applicator to wipe a high concentration, low volume herbicide solution directly on target weeds. The advantage to this method is that one can precisely hit target plants and avoid non-targets even if the non-targets occur in extreme proximity to the targets.

On June 9, 2023, IAE experimented in wiping the flowering stalks of tall oatgrass in a few patches in the NE section. We did this using a 12.5% solution of glyphosate and hand wiped with a sponge (Figure 6, left). Some of the tall oatgrass we wiped occurred directly within a Kincaid's lupine patch, but this was not an issue since the tall oatgrass flowering stalks were at least a half-meter taller than the Kincaid's lupine racemes. This proved to be a labor-intensive but highly effective control method. When we

checked efficacy a few weeks later, it was clear that the patches we targeted were dead and senesced (Figure 6, right) while non-wiped patches nearby were still green and standing upright.

Moving forward, weed wiping tall oatgrass may be a useful technique to employ with a contract crew, at least to eliminate some of the small patches that occur sporadically across the eastern half of the site. In areas such as the SW section where tall oatgrass is far more widespread, this technique would be too inefficient. In those areas, well-timed fall broadcast sprays of glyphosate may be the best control method until grass-specific herbicides are approved for use on BLM lands. Currently, grass-specific herbicides are only allowed for research purposes. However, these would be an extremely effective tool to target tall oatgrass without harming Kincaid's lupine if they were allowed to be used more broadly.

Figure 6. (Left): Weed wiping tall oatgrass (*Arrhenatherum elatius*) flowering stalks by hand using a sponge on June 9, 2023. (Right): A dead patch of tall oatgrass on June 27, several weeks after weed wiping. The flowering stalks collapsed and vegetative material was completely senesced while adjacent, unwiped patches were still green with erect stems.

3.2.2. False dandelion

False dandelion (also referred to as hairy cat's ear) is a non-native perennial forb in the Asteraceae family that is a serious weed in lawns, pastures, and grasslands. It forms a low-lying rosette around a central taproot. False dandelion can be problematic because it can flower nearly any time of year, its

seed set is prolific, and its rosette structure occupies a lot of ground space which essentially leads to monocultures.

At Fir Butte, false dandelion has increased in abundance across the SE section management unit since the 2018 prescribed burn, which received limited follow-up herbicide treatments for several years and did not receive a native seed addition until 2021. Along the northern edge of the SE management unit, false dandelions have nearly created a monoculture. However, small Kincaid's lupine seedlings from 2021 have starting germinating within these dense false dandelion patches (Figure 7), making them extremely difficult to manage without adversely impacting the Kincaid's lupine.

In 2023, IAE began aggressively treating false dandelion at Fir Butte using a variety of methods. Across the NE section, we targeted false dandelion alongside other species such as tall oatgrass during post-burn spot spray efforts in March and June. In the SE section in April, we thoroughly examined dense patches of false dandelion for any Kincaid's lupine or other native seedlings. Where we found none, we sprayed glyphosate liberally to kill off large patches. Where Kincaid's lupine occurred within patches, we used a weed dabber stick with a sponge end to wipe false dandelion rosettes without adversely affecting non-target species. However, this method did not appear to be consistently effective during a follow-up efficacy check, likely because the volume applied with the dabber was minimal and we only used a low concentration spot spray rate.

By early June 2023, the false dandelion was flowering in abundance and beginning to set seed. To limit seed raining onto nearby bare ground, IAE and Colin Sayre of the BLM hand pulled and used weeding sickles to cut and bag flowering heads across a dense half-acre patch in the SE section. Although this method effectively reduced seed set and opened more bare ground, many of the false dandelion rosettes produced additional rounds of flowering stems throughout the summer.

Moving forward, false dandelion may be one of the most critical weeds to control at this site. Given its low stature and proximity to many Kincaid's lupine and other native seedlings, it is proving to be challenging to manage. Fall and winter spot sprays (November through February) when the false dandelion is green, but Kincaid's lupine has yet to emerge, may be the best time to target this weed, since one could spray large patches effectively while minimizing impacts on non-target species. The trade-off with winter sprays is that treatment efficacy tends to be reduced due to low temperatures.

Figure 7. A dense stand of false dandelion (*Hypochaeris radicata*) in the southeast management unit at Fir Butte in June 2023. The purple arrow marks a Kincaid's lupine (*Lupinus oreganus*) seedling growing within the false dandelion, making management of this weed extremely difficult.

3.2.3. Non-native annual grasses

Non-native annual grasses in the western Pacific Northwest can be problematic for native prairie management because they tend to be early season, winter-annual species that germinate and cover a lot of ground before native prairie species. They are currently expanding with hotter, drier conditions (Reed et al. 2021, Reed and Hallett 2023) and can quickly colonize burned habitats.

Ripgut brome (*Bromus diandrus*) and rattail fescue (*Vulpia myuros*) are two of the common non-native annual grasses at Fir Butte. Ripgut brome is widespread across the NE management unit, but it tends to not get taller than Kincaid's lupine and has not been growing in dense stands at this site (Figure 8). As a result, it has not been a primary target for weed control other than occasional sprays when targeting higher-priority species like tall oatgrass.

Figure 8. The northeast (NE) section at Fir Butte in May 2023. The section is dominated by Kincaid's lupine (*Lupinus oreganus*) following the fall 2022 prescribed burn. Ripgut brome (*Bromus diandrus*) is relatively common across the NE section and can be seen flowering in this photo. However, it has not been especially problematic to date as it tends to not get taller than Kincaid's lupine and has not been growing in dense stands.

Like the false dandelion, rattail fescue has been increasing in abundance across the SE management unit over the past several years. This species is a high priority weed because it creates thick mats of litter that make it extremely difficult for native species to establish from seed. In 2023, IAE targeted rattail fescue with glyphosate spot sprays in March and April. In the SE section, we liberally sprayed large patches of it where there were no Kincaid's lupine seedlings present, using plant shields to avoid impacting non-target species (Figure 9). Rattail fescue tends to set seed and senesce by mid-May, so the best times to target this species are fall (after green up) and early spring.

Rattail fescue tends to occur in patches alongside false dandelion and Queen Anne's lace at Fir Butte, creating a trifecta of undesirable weeds. Where these weeds are at their worst, we should consider resetting these areas by completing two years of broadcast glyphosate treatments with at least two to three sprays per year, followed by heavy seeding with a native seed mix including species that can

germinate and occupy space quickly. If grass-specific herbicides are given approval for use on BLM lands, these tools may help manage some non-native annual grasses. However, it is worth noting that fine-leaved grasses like rattail fescue tend to be resistant to many grass-specific herbicides.

Figure 9. Dead patches of rattail fescue (*Vulpia myuros*) in the SE section at Fir Butte in May 2023 following April spot spray treatments. Plant shields were used to avoid impacting native species.

A third non-native annual grass species found at Fir Butte is wild oat (*Avena fatua*). This grass is far less abundant than ripgut brome and rattail fescue but occurs in a few dense clusters across the site. On June 15, IAE hand-pulled the largest patch of wild oat just before seed ripening (Figure 10). This species tends to occur in sandy soils, making it extremely easy to pull. This resulted in a large patch of bare ground that was perfect for fall 2023 seeding.

Figure 10. Before (left) and after (right) hand-pulling a dense patch of wild oat (*Avena fatua*) on June 15, 2023 at Fir Butte.

3.2.4. Woody species

The most abundant and problematic woody species at Fir Butte is Himalayan blackberry. Hawthorn (*Crataegus* sp.), rose (*Rosa* sp.), and Scotch broom are less abundant but also critical to control as they can spread quickly and reduce the quality of prairie habitat for Kincaid's lupine and Fender's blue butterfly. Woody encroachment is a constant threat in Willamette Valley prairies and is typically controlled through a combination of prescribed burning, mowing, and herbicide application.

Historically, Himalayan blackberry cover was extremely high across Fir Butte and was controlled through the early 2000's and 2010's by cutting, mowing, and masticating. Between 2019-2021, IAE contracted spot-spray crews to target Himalayan blackberry and other woody species, which effectively reduced blackberry cover to <5% for the first time since monitoring began in 1998 (Fields et al. 2022), achieving one of the specific restoration goals for the site. As of 2023, woody cover remains below the <5% target threshold (see Section 4.2.2 below). In August 2023, IAE once again hired a contractor (R. Franco Restoration) to spot spray woody vegetation across the entire site.

3.2.5. Meadow knapweed

Meadow knapweed is a non-native perennial forb in the Asteraceae family that is an extremely aggressive invader of grassland and pasture systems. It is mostly located in patches throughout Fir Butte, especially along the outer perimeter of the site. Despite ongoing efforts to eliminate it from the site, meadow knapweed remains a persistent threat due to its prevalence on neighboring properties along Fir Butte Road. Complete control of this species at Fir Butte will only be achieved by creating partnerships with neighboring landowners to ensure that the entire population is treated.

Prior to the BLM approving herbicide use in 2018, IAE would cut, bag, and remove meadow knapweed stems multiple times during the growing season to reduce seed set at the site. This method is successful for reducing seed set, but it does not kill the plant and requires substantial time and effort. Mowing before plants reach maturity can reduce plant vigor, but mowed plants will produce flowers lower to the ground,

making them more difficult to treat in the future. Grubbing can be successful if the entire root system is removed, but this process is also labor intensive and results in substantial ground disturbance. Dennehy et al. (2011) recommended manual removal of meadow knapweed only when herbicides are not available and emphasized the need to remove all roots. As an alternative to manual removal, herbicide is an efficient and successful treatment method when applied at the rosette to bud stage in spring.

IAE began spot spraying meadow knapweed with glyphosate in December 2018 and continued treatments in each spring 2019-2023. Between April to June 2023, IAE spot-sprayed meadow knapweed across the site whenever found. However, we did not encounter more than approximately 10 plants to spray in total. Later in the summer, we also hand pulled a handful that we found while visiting the site without herbicide.

3.2.6. Queen Anne's lace

Queen Anne's lace (also known as wild carrot) is a widespread non-native biennial forb in the Apiaceae family. Like false dandelion, Queen Anne's lace seed set is prolific. It can germinate throughout the growing season, and it often forms dense patches of basal leaves around the time that critical native species such as Kincaid's lupine are emerging (Figure 11). However, its peak growth and flowering time occurs later in the summer (typically July-August).

Figure 11. A dense patch of Queen Anne's lace (*Daucus carota*) basal leaves in the Southeast management unit at Fir Butte in April 2023. The purple arrow marks a Kincaid's lupine (*Lupinus oreganus*) growing within the Queen Anne's lace.

In general, Queen Anne's lace has not been a major focus of weed treatment efforts in native prairie systems because of its later phenology and seemingly minor impact. It is also one of the few nectar

resources available for late-season pollinators in August. However, its abundance across the SE section at Fir Butte in recent years seems to be making it difficult for native seedlings from the 2021 seeding effort to establish. As a result, IAE began targeting Queen Anne's lace where appropriate in 2023.

Queen Anne's lace commonly occurs alongside patches of false dandelion and rattail fescue at Fir Butte. When spot-spraying for those weeds in spring 2023, IAE also sprayed Queen Anne's lace in the vicinity. On July 13, IAE, the BLM, and the Lane-Metro Youth Corps hand-pulled all the Queen Anne's lace from the same half-acre area in the SE section as was targeted when hand-pulling/cutting false dandelion on June 15 (Figure 2; Figure 12). These efforts substantially increased bare ground across that area, setting it up nicely for fall 2023 seed and native plant additions (described below).

Figure 12. A half-acre area within the southeast section at Fir Butte after hand-pulling all the Queen Anne's lace (*Daucus carota*) on July 13, 2023. A wall of Queen Anne's lace can be seen flowering in the background.

3.2.7. Bracken fern

Bracken fern, although native, is a species of concern at Fir Butte. The population had been increasing for a few years and there was concern that it could outcompete Kincaid's lupine and impede access of Fender's blue butterflies to Kincaid's lupine and nectar resources. In previous years, bracken fern was mowed and hand pulled (Fields et al. 2022). However, mowing alone was not sufficient to keep pace with bracken fern as new fronds continued to grow through the summer. The West Eugene Wetlands Biological Opinion 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 (U.S. Fish and Wildlife Service 2014).

Milligan et al. (2016) found that it took six to eight years of repeated treatments (cutting via a string trimmer or herbicide applications) to eliminate bracken fern from heavily infested grassland areas. Cutting (twice or thrice a year) was equally as effective at reducing bracken fern cover and density as a one-time broadcast herbicide application followed by annual spot spraying of emerging fronds. In both

cases, the greatest decline in bracken fern cover occurred after the first year of treatment. But because bracken fern is rhizomatous, achieving elimination requires a committed effort to deplete carbohydrate resources over multiple years.

In August 2021, IAE spot treated bracken fern across Fir Butte with glyphosate. By August 2022, bracken fern cover was considerably reduced and was not retreated due to time constraints. However, the entire site was mowed on September 2, 2022 (earlier than in previous years), while most bracken fern was still green. IAE did not target bracken fern in 2023 as its cover continues to remain low (see Section 4.2.2 below). In future years, retreatment with herbicide, early mowing, and/or cutting with string trimmers may be necessary if it begins to rebound.

3.3. Seeding

In 2023, IAE seeded a total of 107 lbs of a diverse native prairie seed mix composed of 25 species (Table 2). This seed came from a combination of the BLM's inventory at the West Eugene Wetlands Red House cooler and requests from the City of Eugene nursery. The mix included an abundance of Fender's blue butterfly nectar species (e.g., Oregon sunshine (*Eriophyllum lanatum*), Oregon iris (*Iris tenax*), barestem biscuitroot (*Lomatium nudicaule*), and dwarf checkermallow), but species selection and quantities were limited by availability.

We broadcast seeded the mix using belly-bag spreaders on two different dates across a total of seven acres: all six acres of the NE management unit that burned in fall 2022, and approximately one acre across the SE management unit where 2023 treatments provided optimal bare ground for seeding. On October 6, we seeded 77 lbs across all seven acres at a rate of approximately 11 lbs/acre. During this seeding effort, we noted a few patches across the NE section where non-native grasses such as ripgut brome were beginning to green up substantially and occupy most of the residual bare ground from the burn. To counteract this, we returned on October 13 and spot-sprayed these patches (a total of ~1.5 acres) with glyphosate, then broadcast the remaining 30 lbs of seed over top. This strategy of spot spraying and overseeding will hopefully prevent dense areas of non-native grasses from establishing.

In future years, we recommend adding seed any time there is a substantial disturbance (e.g., a prescribed burn or widespread herbicide treatments). Doing so will help prevent weeds establishing and will increase native nectar diversity and abundance for the Fender's blue butterfly. In years when a prescribed burn occurs, we strongly recommend seeding the unit within a month of the burn. There is never a better opportunity to seed than shortly after the burn due to the abundance of bare ground. If weather conditions cooperate, it can sometimes be beneficial to do a broadcast herbicide treatment within a month following the burn but before seeding to target non-native species that green up faster than natives. Even if a broadcast herbicide treatment cannot be achieved, we recommend seeding the same year as the burn.

Furthermore, having specific funds allocated for purchasing seed would be extremely helpful. The quantity and variety of seed currently available in BLM inventory and through the City of Eugene nursery is somewhat limited relative to what is grown on an annual basis from a variety of commercial seed producers. For example, there were few native grasses to choose from that be appropriate for upland habitat at Fir Butte other than small quantities of California oatgrass (*Danthonia californica*) and Roemer's fescue (*Festuca roemeri*). Some of the seed in inventory also dates to 2015 and may therefore be of questionable viability. Having funds to purchase even small quantities of seed each year would go a long way toward boosting native plant diversity and abundance at Fir Butte.

Table 2. Seed mix broadcasted across seven acres at Fir Butte in fall 2023.

Scientific Name	Common Name	Form	Duration	Quantity (lbs)
Achillea millefolium	common yarrow	Forb	Perennial	0.44
Allium amplectens	narrow-leaf onion	Forb	Perennial	3.64
Camassia leichtlinii	tall camas	Forb	Perennial	12.21
Carex tumulicola	splitawn sedge	Sedge	Perennial	0.75
Clarkia purpurea ssp. quadrivulnera	winecup clarkia	Forb	Annual	0.62
Collomia grandiflora	large-flowered collomia	Forb	Annual	7.00
Danthonia californica	California oatgrass	Grass	Perennial	4.57
Epilobium densiflorum	denseflower willowherb	Forb	Annual	1.50
Eriophyllum lanatum	woolly sunflower	Forb	Perennial	2.12
Festuca roemeri	Roemer's fescue	Grass	Perennial	3.47
Iris tenax	toughleaf iris	Forb	Perennial	14.50
Lomatium nudicaule	barestem biscuitroot	Forb	Perennial	14.00
Madia elegans	showy tarweed	Forb	Annual	3.00
Perideridia oregana	Oregon yampah	Forb	Perennial	1.36
Plectritis congesta	shortspur seablush	Forb	Annual	2.44
Potentilla gracilis	slender cinquefoil	Forb	Perennial	2.00
Prunella vulgaris var. lanceolata	common selfheal	Forb	Perennial	2.25
Ranunculus occidentalis	western buttercup	Forb	Perennial	2.75
Sidalcea malviflora ssp. virgata	dwarf checkermallow	Forb	Perennial	11.76
Sisyrinchium idahoense	Idaho blue-eyed grass	Forb	Perennial	3.5
Triteleia hyacinthina	Hyacinth brodiaea	Forb	Perennial	3.47
Wyethia angustifolia	mule ears	Forb	Perennial	9.50
			Total	**106.85**

3.4. Planting

In addition to seeding, we added Fender's blue butterfly nectar to Fir Butte by planting plugs, bulbs, and bareroot plants. In March 2023, the City of Eugene nursery donated approximately 700 dwarf checkermallow bareroot plants which IAE, the BLM, and the Lane-Metro Youth Corps planted across two locations in the NE management unit (Figure 2). On November 10, IAE held a volunteer planting event that was attended by 12 volunteers (Figure 13). During this event, we planted approximately 150 additional dwarf checkermallow plants from the City of Eugene, thousands of narrowleaf onion (*Allium amplectens*) bulbs donated by Heritage Seedlings and Liners, Inc. (Heritage), 1,000 Tolmie star-tulip bulbs purchased from Heritage, as well as 216 Oregon sunshine plugs, 400 Oregon geranium (*Geranium oreganum*) roots, 300 Oregon iris seedlings, and 300 barestem biscuitroot tubers ordered through SevenOaks Native Nursery.

All seven species planted at Fir Butte are excellent native perennial nectar species for the Fender's blue butterfly. Tolmie star-tulip and Oregon geranium are two species that have not been previously found at the site, but we felt they would be worth trying to establish there. We spread the November 10 plants

across six different locations in the NE and SE sections of the site (Figure 2). We selected planting locations based on where we felt conditions were suitable to support survival as well as where nectar resources were relatively scarce.

Figure 13. Demonstrating how to plant with a soil knife during a volunteer planting event at Fir Butte on November 10, 2023. Photo credit: Lina Batas.

4. 2023 MONITORING AND HABITAT ASSESSMENT

In 2023, IAE monitored the Kincaid's lupine population as well as the entire upland prairie plant community at Fir Butte using the methods described below.

4.1. Methods

4.1.1. Kincaid's lupine monitoring methods

ORIGINAL PLOT DESIGN

In 1998, a 216m x 288m macroplot was established covering the entire area occupied by Kincaid's lupine at Fir Butte. This macroplot was further divided into 18 subplots, each 24m x 108m with the long axis running west to east (Figure 14). Within each of the 18 subplots were two nested 100m belt transects (n = 36) surrounded by a 2m wide buffer on each of the long sides and a 4m wide buffer on each of the narrow sides. Transects were marked on both ends with concrete markers. Corners of the macroplots were marked with t-posts or concrete markers. Each fence post or marker was labeled with a pre-numbered aluminum tag. Additional information regarding initial plot establishment can be found in Thorpe (2011).

Currently, IAE continues to monitor the site using these transects. From 1998-2010, both the north and south sides of each transect were monitored for Kincaid's lupine cover and target weed species. Since 2011, only the north side of the transects are being monitored.

2023 MONITORING METHODS

In 2023, IAE estimated the Kincaid's lupine foliar cover by measuring the approximate rectangular area occupied by a cluster of plants in centimeters. Population estimates for Kincaid's lupine were made by averaging the data across all monitored transects (n = 36) and multiplying by the total number of possible 100m belt-transects at the site (n = 460). Each 100m transect was divided into 5m sections. The foliar cover and count of mature and aborted racemes were recorded for each 5m section. Additionally, staff noted the presence of Kincaid's lupine seedlings observed in the monitoring transects.

Figure 14. Plot layout for Kincaid's lupine (*Lupinus oreganus*) monitoring at Fir Butte. The entire occupied portion of the site is divided into 18 subplots. Two 100m belt-transects are monitored in each subplot in 1m x 5m sections.

4.1.2. Vegetation community monitoring methods

Vegetation community monitoring activities were guided by 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 2023, habitat monitoring focused on evaluating target weed species presence and percent cover along Kincaid's lupine monitoring transects and plant functional group cover in a randomly selected location along each monitoring transect. Monitoring the plant community in each of the monitoring transects allows for an assessment of changes in response to management treatment and provides pre-treatment data for portions of the site which are scheduled to receive management treatments in the near future.

PERCENT COVER OF TARGET WEED SPECIES IN KINCAID'S LUPINE TRANSECTS

In conjunction with Kincaid's lupine monitoring in 2023, we recorded the percent cover of Himalayan blackberry, bracken fern, hedge bindweed (*Calystegia sepium*) and the presence/absence of meadow knapweed, in the same 5m sections used to monitor Kincaid's lupine. We calculated confidence intervals for the percent cover estimates by considering the average cover for each species in each transect. These measurements allow us to quantify changes in weed species cover and assess management effects in conjunction with changes in Kincaid's lupine cover.

PERCENT COVER BY SPECIES

In 2023 we monitored a $1m^2$ quadrat to the species level in two randomly selected locations along each monitoring transect. Random numbers were generated between 0-99, and the quadrat was placed on the north side of the tape at the meter mark of the randomly generated number. We assessed the percent cover of all vascular plants and five ground cover types. Ground cover classes are equal to 100% and include bare soil, litter, rock, moss, and basal vegetation. We visually estimated percent cover to the nearest 1%; for species occurring at <1% cover, we estimated cover to 0.1% or 0.5%. Species names and supplementary information followed the USDA Plants Database (plants.usda.gov/home) and local floras.

4.2. Results

4.2.1. Kincaid's lupine monitoring results

Kincaid's lupine cover at the site has trended upward since monitoring began in 1998. In 2023, the estimated Kincaid's lupine cover was $6{,}701m^2$ ($\pm 2{,}739$) (Figure 15, Table 4). Raceme count has followed a similar upward trend with an estimated 148,133 ($\pm 60{,}301$) mature racemes in 2023 (Figure 15, Appendix 7).

Figure 17 shows the relative change in Kincaid's lupine cover in each of the management treatment units (NE, SE, SW). The NE and SE sections of the site, which have received more intensive management (including prescribed burns), have shown a greater increase in Kincaid's lupine cover than the unburned SW section of the site. Since 2018, herbicide use has been used more frequently in the NE and SE sections and these areas have shown a two-to-three-fold increase in Kincaid's lupine cover as compared to the SW section.

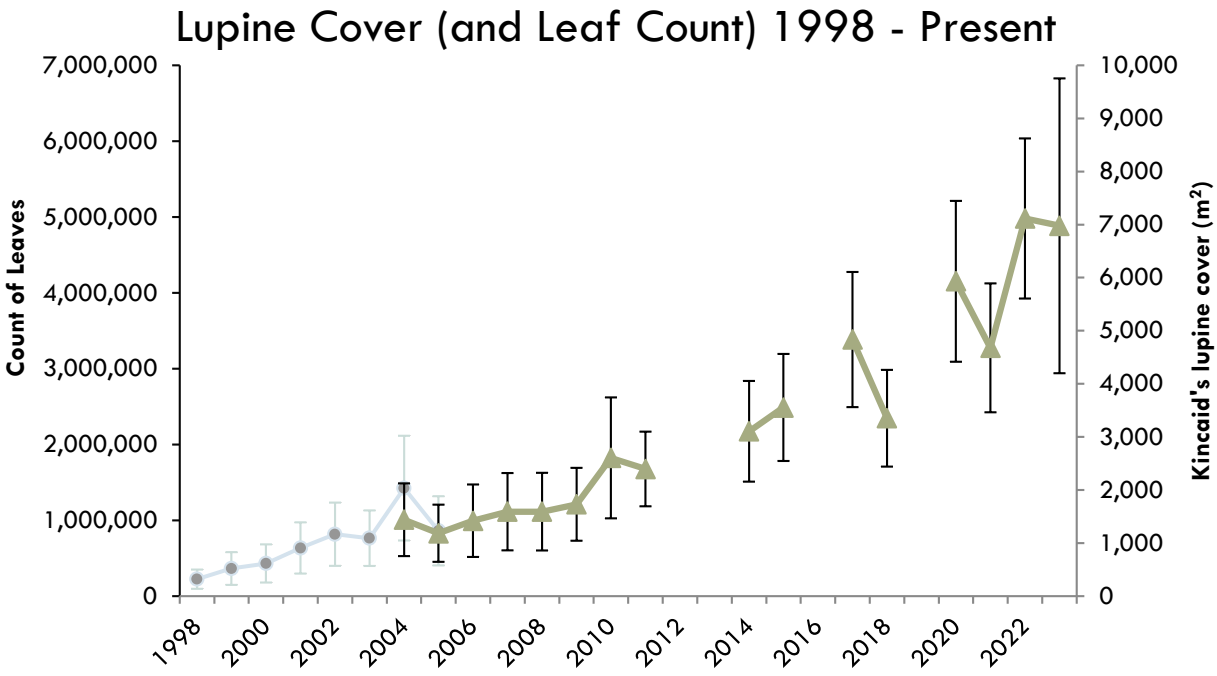


Figure 15. Kincaid's lupine (*Lupinus oreganus*) foliar cover (green lines; triangles) and leaf counts (grey lines; circles) at Fir Butte from 1998-2023. Error bars represent 95% confidence intervals. Data was not recorded every year.

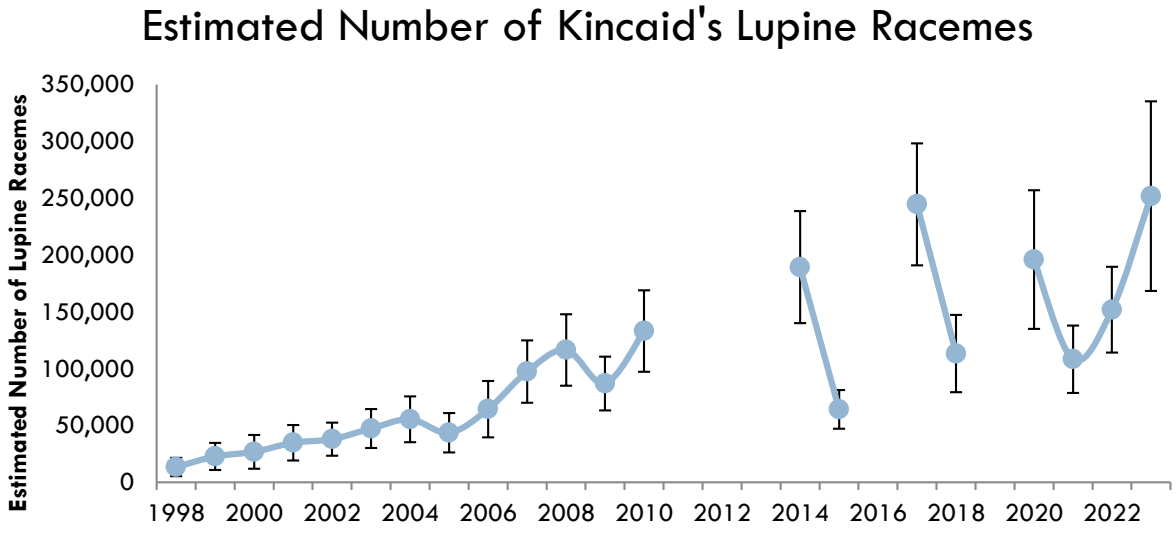


Figure 16. Estimated number of mature Kincaid's lupine (Lupinus oreganus) racemes at Fir Butte from 1998-2023. Data was not recorded every year. Error bars represent 95% confidence intervals.

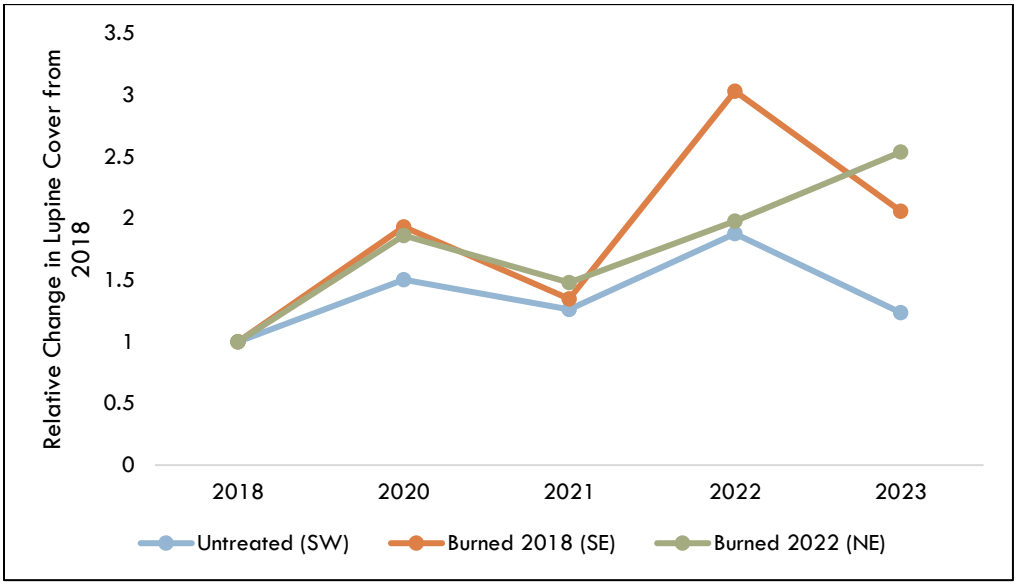


Figure 17. Proportional change in Kincaid's lupine (*Lupinus oreganus*) cover in the treated (SE and NE) and untreated (SW) portions of the habitat from 2018 to present. Since 2018 when herbicide use was first permitted, we have been treating the NE and SE sections far more extensively than the SW section.

4.2.2. Vegetation community monitoring results

PERCENT COVER OF TARGET WEED SPECIES IN KINCAID'S LUPINE TRANSECTS

In 2023, the average Himalayan blackberry percent cover in Kincaid's lupine transects was 1.2% (±1.2%) (Figure 18; Table 3). In 2020-2023, Himalayan blackberry percent cover was below the 5% threshold for meeting recovery requirements as defined in the Habitat Recovery Plan (U.S. Fish and Wildlife Service 2010).

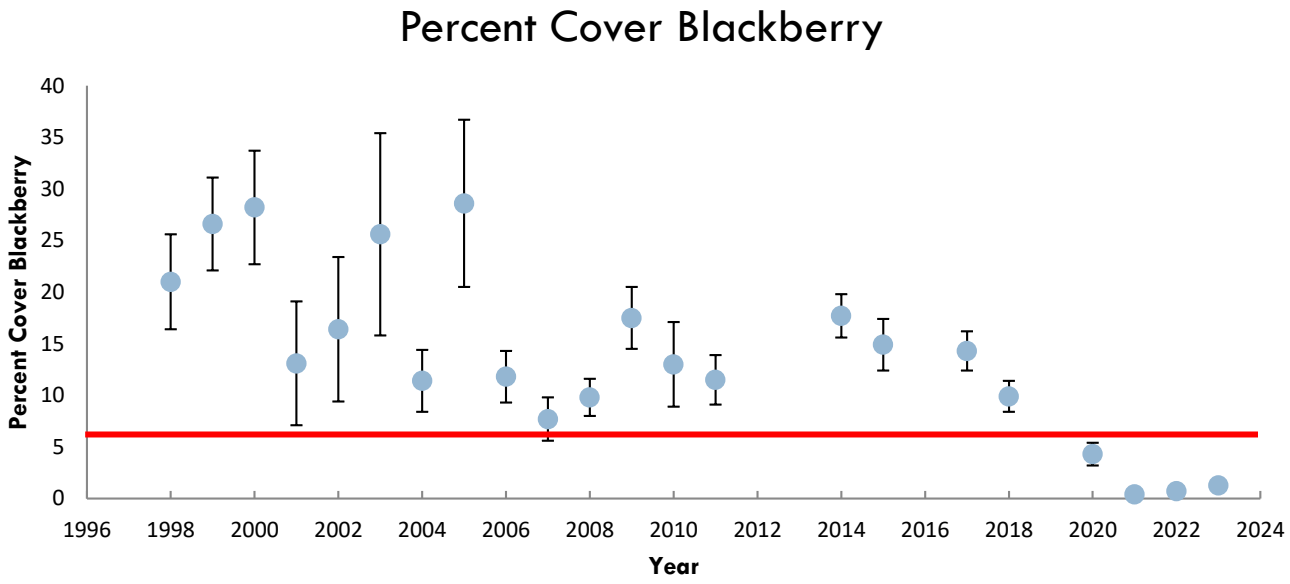


Figure 18. Himalayan blackberry (*Rubus bifrons*) percent cover at Fir Butte from 1998 to 2023. The red line represents the 5% cover management threshold. Data was not collected every year. Error bars represent 95% confidence interval; error bars in 2021-23 are small and thus not visible at the scale of this graph (Table 2).

In 2023, bracken fern cover remained low at less than 1% (0.9 ±0.6%, Table 3). Between 2011-2021, meadow knapweed was observed in at least one transect every year that it was monitored. In 2022, meadow knapweed was not observed in any of the subplots. In 2023, however, 33 subplots were noted to contain knapweed (Table 3). Most knapweed was noted in the western half of the site (in transects 16-18), as well as the southern edge of the site (transects 1 and 13).

For hedge bindweed, the average cover across all transects decreased from 1.7% (±1.9%) in 2022 to 0.9% (±1%) in 2023 (Table 3). This species continues to only be observed in patches within the western portion of the Kincaid's lupine habitat, where some subplots have hedge bindweed cover as high as 80%.

Table 3. Himalayan blackberry (*Rubus bifrons*), tall oatgrass (*Arrhenatherum elatius*), bracken fern (*Pteridium aquilinum*), and hedge bindweed (*Calystegia sepium*) percent cover, and quantity of plots (out of 720 in total) with meadow knapweed (*Centaurea pratensis*) present, at Fir Butte along 100m x 1m transects monitored from 1998 to present. "-" indicates data was not collected that year.

Year	Average % cover								# 5m x 1m plots with meadow knapweed present
	Himalayan blackberry		Tall oatgrass*		Bracken fern		Hedge bindweed		
	Average cover	95% CI	Average cover	95% CI	Average cover	95% CI	Average cover	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	-	-	5
2012	-	-	-	-	-	-	-	-	-
2013	-	-	-	-	-	-	-	-	-
2014	17.7	2.1	-	-	4.2	2.1	-	-	2
2015	14.9	2.5	-	-	3.6	1.5	-	-	3
2016	-	-	-	-	-	-	-	-	-
2017	14.3	1.9	14.6	4.9	4.9	2.3	-	-	4
2018**	9.9	1.5	9.0	4.6	3.4	1.7	2.1	2.0	2
2019	-	-	-	-	-	-	-	-	-
2020	4.3	1.1	16.2	6.2	2.6	1.1	2.3	2.1	3
2021	0.4	0.1	12.2	5.5	1.1	0.6	0.9	1.0	3
2022	0.7	0.2	-	-	0.2	0.2	1.7	1.9	0
2023	1.3	0.5	18.8	8.8	0.9	0.6	0.9	1	33

* Prior to 2017, only presence/absence of tall oatgrass was recorded in the 5m sections for 100m transects.
** In 2018, the site was mowed with a string trimmer prior to monitoring.

PERCENT COVER BY MANAGEMENT SECTION

Data here is presented in three sections: the SE section (burned in the fall of 2018), NE section (burned in fall of 2022) and the SW section (not burned in the recent past). Data is reported as absolute cover by functional group (Table 4), relative cover by functional group (Table 5), and absolute cover of select species (Table 6).

Southeast section (2018 burn unit):

Data was collected for the SE management unit in 2018 (before a prescribed burn) and 2020-2023 (after burn treatments). Following the prescribed burn, the absolute cover of bare ground increased and has remained higher than values recorded prior to the burn (Table 4). The absolute cover of shrubs has decreased since 2020 and now remains below 1%. The absolute cover of introduced graminoids decreased from 2022-2023 from 44.1% (±11.1%) to 29.7% (±13.8%), and now equals the cover from just before the burn (2018). The absolute cover of introduced forbs decreased from 2022-2023 from 28.9% (±10.6%) to 20.6% (±8.8), but still remains higher than in 2018 before the burn (9.8% ±3.7%). The absolute cover of native forbs decreased from 2022-2023 from 6.1% (±4.2%) to 4.9% (±2.8%), but still remains higher than in 2018 before the burn (2.5% ±1.3%).

Introduced forbs and graminoids remained the dominant functional groups in the SE section in 2023, collectively making up 85% of the relative cover (Table 5). Native forbs follow at 11.1% (±5.7%).

Northeast section (2022 burn unit):

Data was collected for the NE management unit in 2023, following a prescribed burn in the fall of 2022. Following the burn, the absolute cover of bareground was 39.6% (±8.5%), and absolute cover of litter was 19.6% (±6.7%) (Table 4).

As for relative cover, native forbs were the most dominant functional group within the NE section in 2023 (36.5% ±10.1%). This was largely driven by Kincaid's lupine (Table 6). Introduced grasses were next at 33.0% (±7.7%), followed by introduced forbs (26.2% ±7.0%), trees/shrubs (3.3% ±2.5%), and ferns (0.9% ±1.8%).

Southwest section (no prescribed burn):

Data was collected for the SE management unit, where there has been no prescribed burning, in 2023. For relative cover, introduced graminoids are by far the dominant functional group in this section at 77.4% (±10.0%) (Table 5). Introduced forbs follow at 12.4% (±6.7%), then native forbs at 8.6% (±7.6%), trees/shrubs at 1.3% (±1.1%), and finally ferns at 0.3% (±0.3%).

Table 4. Average absolute percent cover by functional group and ground cover class in the southeast (SE) section at Fir Butte in 2018 (pre-burn) and 2020-2023 (post-burn), and in the northeast (NE) and southwest (SW) sections in 2023. Values in parentheses represent 95% confidence intervals.

	SE Section					NE Section	SW Section
Functional Group	**2018**	**2020**	**2021**	**2022**	**2023**	**2023**	**2023**
Introduced Forbs	9.8 (3.7)	15.6 (5.8)	22.6 (5.6)	28.9 (10.6)	20.6 (8.8)	12.7 (4.1)	9.9 (5.2)
Native Forbs	2.5 (1.3)	5.7 (4.0)	4.5 (2.2)	6.1 (4.2)	4.9 (2.8)	20.7 (7.2)	5.7 (5.4)
Introduced Graminoids	19.8 (4.8)	17.8 (9.3)	4.3 (1.4)	44.1 (11.1)	29.7 (13.8)	16.4 (4.6)	69.0 (14.9)
Native Graminoids	0.0 (0.0)	0.4 (0.4)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
Fern	3.1 (2.5)	2.3 (3.1)	1.5 (1.7)	0.3 (0.4)	1.2 (1.6)	0.7 (1.4)	0.2 (0.2)
Tree/shrub	3.7 (2.4)	9.0 (8.3)	1.9 (1.5)	0.3 (0.4)	0.6 (0.7)	1.3 (1.0)	0.9 (0.7)
Bareground	1.0 (1.0)	14.8 (8.0)	20.0 (9.3)	12.8 (7.3)	9.2 (5.5)	39.6 (8.5)	4.9 (4.5)
Litter	64.7 (5.7)	34.2 (7.3)	54.1 (10.2)	48.9 (7.6)	50.4 (12.1)	19.1 (6.7)	46.3 (9.4)

Table 5. Relative percent cover by functional group in each of the three management units in 2023. Values in parentheses represent 95% confidence intervals.

	SE Section					NE Section	SW Section
Functional Group	2018	2020	2021	2022	2023	2023	2023
Introduced Forbs	24.4 (8.0)	42.9 (12.6)	62.1 (7.8)	36.0 (11.2)	40.2 (10.7)	26.2 (7.0)	12.4 (6.7)
Native Forbs	6.6 (3.5)	11.6 (5.3)	13.1 (4.8)	7.2 (4.7)	9.8 (5.1)	36.5 (10.1)	8.6 (7.6)
Introduced Graminoids	50.8 (9.6)	30.6 (11.2)	18.8 (7.1)	56.1 (12.8)	47.1 (11.5)	33.0 (7.7)	77.4 (10.0)
Native Graminoids	0.0 (0.0)	0.6 (0.6)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
Fern	9.1 (5.7)	3.8 (4.3)	3.0 (3.4)	0.3 (0.5)	2.3 (3.1)	0.9 (1.8)	0.3 (0.3)
Tree/shrub	9.1 (4.8)	10.4 (7.5)	3.7 (2.5)	0.5 (0.6)	0.7 (0.8)	3.3 (2.5)	1.3 (1.1)
Meeting Recovery Criteria? (Introduced cover <50% relative cover)	No	No	No	No	No	No	No

Table 6. Select species absolute percent cover recorded in all 1m^2 quadrats in the southeast (SE) section at Fir Butte in 2018 and 2020-2023, and in the northeast (NE) and southwest (SW) sections in 2023. Values in parentheses represent 95% confidence intervals.

Species	Functional Group	SE Section					NE Section	SW Section
		2018	2020	2021	2022	2023	2023	2023
Agrostis capillaris	Graminoid	13.1 (4.7)	12.1 (8.2)	1.5 (0.8)	6.2 (7.1)	12.6 (7.8)	3.1 (1.9)	18.8 (9.5)
Anthoxanthum odoratum	Graminoid	*0.9 (1.0)	1.2 (1.2)	0.3 (0.5)	3.2 (4.2)	0.2 (0.3)	0.1 (0.1)	0.0 (0.0)
Arrhenatherum elatius	Graminoid	0.5 (0.4)	3.4 (2.9)	0.1 (0.1)	0.3 (0.7)	5.2 (5.4)	4.5 (3.8)	32.3 (11.5)
Bromus diandrus	Graminoid	0.3(0.4)	0.2(0.2)	0.1(0.1)	0.0(0.0)	0.2(0.2)	6.0 (1.8)	0.4 (0.4)
Dactylis glomerata	Graminoid	0.5 (0.5)	0.2 (0.4)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.6 (0.9)
Festuca arundinacea	Graminoid	1.2 (1.4)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
Vulpia myuros	Graminoid	2.8 (2.1)	0.1 (0.2)	0.8 (0.6)	14.6 (6.3)	9.8 (6.1)	2.4 (1.5)	14.7 (7.4)
Crepis capillaris	Forb	3.7 (2.6)	3.6 (2.1)	8.0 (3.7)	2.5 (1.3)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
Daucus carota	Forb	0.4 (0.3)	2.1 (1.6)	2.9 (2.7)	10.3 (8.3)	6.5 (3.9)	3.4 (3.6)	4.9 (2.9)
Hypochaeris radicata	Forb	1.6 (0.7)	0.6 (0.5)	2.0 (1.8)	10.3 (6.9)	9.9 (7.1)	2.2 (2.0)	0.0 (0.0)
Galium parisiense	Forb	0.4 (0.3)	1.2 (0.7)	6.7 (3.7)	3.0 (1.7)	0.0 (0.0)	1.5 (1.4)	0.0 (0.0)
Pteridium aquilinum	Fern	3.1 (2.5)	2.3 (3.1)	1.5 (1.7)	0.3 (0.4)	1.2 (1.6)	0.7 (1.4)	0.2 (0.2)
Rubus bifrons	Shrub	3.7 (2.4)	9.0 (8.3)	1.9 (1.5)	0.3 (0.4)	0.3 (0.5)	1.3 (1.0)	0.8 (0.7)
Lupinus oreganus	Forb	0.7 (0.6)	3.6 (3.9)	3.2 (2.2)	4.0 (4.2)	4.5 (2.8)	18.0 (7.6)	5.3 (5.4)

*In 2018 tall oatgrass (*Arrhenatherum elatius*) had been weedwhacked prior to monitoring, making the 2018 estimate artificially low.

4.3. Discussion

4.3.1. Kincaid's lupine and target weed species

The foliar cover of Kincaid's lupine remained stable, and the count of Kincaid's lupine racemes increased at the site from 2022 to 2023. Kincaid's lupine cover increased more in the intensively treated sections of the site (NE and SE management units) relative to the SW section, which has received relatively few treatments and has remained unburned. Ongoing efforts to control introduced species and increase native plant cover and diversity have contributed to expanding and enhancing the Kincaid's lupine population at Fir Butte. Continued management of introduced species is recommended to maintain these positive trajectories.

Bracken fern has continued a generally downward trend since habitat management treatments have been implemented for that species. Continued management including mowing and cutting of stems have likely contributed to this observed decline. Himalayan blackberry cover has also decreased in response to management treatments and has remained below the 5% threshold for four consecutive years.

Meadow knapweed was noted in 33 plots in 2023 (up from zero in 2022). Most knapweed was noted in the western section of the site and is likely a result of seed dispersal from adjacent property units, as well as the canal access road which has extensive patches of this noxious weed. Continued vigilance will be necessary to prevent further spread of this species. While average cover of hedge bindweed remains relatively low (~1%), some plots have greater than 80% cover with little other vegetation present. Management actions to control the extent of these dense patches should be implemented to ensure that this species does not spread.

4.3.2. Vegetation community monitoring

SOUTHEAST SECTION (2018 BURN UNIT)

The relative cover of introduced species in the SE section remains far above the recovery goal of <50% and has been increasing. One of the primary reasons why habitat conditions have not been improving in the SE section could be that three years passed between the last prescribed burn (2018) and the time the unit was seeded (2021). During that time, most of the herbicide treatments were spot sprays around the existing Kincaid's lupine patches, which allowed some weeds (particularly introduced forbs) to build strength within those untreated patches. Meanwhile, the treated areas were opportunistically colonized by introduced grasses and forbs that did not face much competition because native seed was not put on the ground early enough. Additionally, many of the herbicide treatments occurred during the winter months, when temperatures are too low for treatments to be very efficacious.

Moving forward, continuing to treat non-native species followed by seeding and planting native species in this area, as was done in 2023, is recommended to reach recovery goals. As of 2023, there is still relatively high bare ground cover in this unit (9.2% ±5.5%), providing opportunities to continue seeding with native species. Lastly, continued monitoring will contribute to our understanding of the effects of management treatments on target weed species, Kincaid's lupine, and the overall vascular plant community.

NORTHEAST SECTION (2022 BURN UNIT)

The relative cover of native herbaceous species in the NE section is currently below the recovery goal threshold of >50%, but it is reasonably close at 37.3% (±10.1%). In 2023, following the fall 2022 prescribed burn, the absolute cover of bare ground in this section was 39.6% (±8.5%). This abundance of bare ground was ideal for seeding and planting more native species, which occured in fall 2023. Native forbs were the most dominant functional group within the NE section, largely driven by Kincaid's lupine (Table 6). Other common species included the introduced annual grass soft brome (*Bromus hordeaceus*) and rip-gut brome (*Bromus diandrus*). Continued monitoring efforts in future years should pay attention to these and other non-native species to ensure they do not become problematic.

As for native graminoids, there is some amount of Roemer's fescue (*Festuca roemeri*) across the NE section, but not enough to be picked up during our monitoring efforts (native graminoid cover was 0.0% ±0.0%). In fact, we did not register any native graminoid cover in any of the management units. In the future, adding more native graminoid plant materials to disturbed ground could help boost this functional group. Doing so may also help to outcompete non-native grasses.

SOUTHWEST SECTION (NO PRESCRIBED BURN)

The SW section of the site has not had a prescribed burn in the recent past. We have also performed relatively few herbicide treatments in this management unit (mostly just spot spraying Himalayan blackberry and the occasional meadow knapweed). This portion of the site is dominated by introduced graminoids and has the highest relative cover of introduced graminoids of any of the treatment areas (Table 5). In particular, tall oatgrass is by far the dominant species: (32.3% ±11.5%; Table 6). This portion of the site also has the highest cover of hedge bindweed as observed in monitoring transects as well as in community plots.

The reason for the lack of extensive herbicide treatments targeting non-native grasses in this management unit has been due to the lack of prescribed burning. Small-scale spot spray treatments are minimally effective when the entire management unit is dominated by non-native grasses, especially when there is Kincaid's lupine mixed in. The ideal timing to complete a broadcast herbicide treatment targeting non-native grasses in this section would be following a prescribed burn. Similar to the fall 2022 burn and herbicide treatment in the NE section, the broadcast spray should occur within a month after the burn, at the time when the grasses start to green, but Kincaid's lupine and other natives have yet to emerge.

The SW section was originally planned for a burn in fall 2023. However, plans were postponed to allow the Fender's blue butterfly population more time to rebound following a considerable population decline in 2023. Once the butterfly population has successfully rebounded, we strongly recommend accomplishing a prescribed burn across the SW section, followed by a broadcast herbicide treatment and seeding within the same season.

5. 2024 RECOMMENDED ACTIONS

In 2024, IAE recommends the following habitat restoration and monitoring activities:

- Spot spray through the winter and early spring (before Kincaid's lupine emerges) for tall oatgrass, false dandelion, and other weeds across the NE and SE sections.

- Weed wipe patches of tall oatgrass across the NE and SE sections in June when flowering, especially where it occurs within patches of Kincaid's lupine.
- Continue targeted herbicide applications of meadow knapweed, blackberry, bracken fern, and other non-native species (e.g., hedge bindweed) as necessary throughout the site.
- Work with BLM and the City of Eugene to coordinate treatment of meadow knapweed on neighboring properties.
- Continue hand pulling meadow knapweed, bull thistle, tansy ragwort, and Scotch broom as necessary.
- Begin applications of grass-specific herbicides if BLM receives approval for use.
- Work with neighbors to spray, mow, and masticate Himalayan blackberry along southern and eastern fence lines.
- Seed and plant bare ground in fall 2024 with a diversity of native prairie species. Emphasize Fender's blue butterfly nectar species as well as native graminoids, since the site is lacking considerably in native graminoid cover.
- Continue monitoring the NE, SE, and SW management units to evaluate efficacy of ongoing management actions.
- Hold biannual IAE-BLM meetings to coordinate restoration treatments at Fir Butte.
- Plan to complete a prescribed burn across the SW section in fall 2024 if the Fender's blue butterfly population rebounds in spring 2024.
- If the SW section burns, follow up the burn with a broadcast glyphosate treatment (within one month) and seed the unit within the same season as the burn. Continue aggressively spot spraying tall oatgrass in the months following the burn.

REFERENCES

Dennehy, C., E. R. Alverson, H. E. Anderson, D. R. Clements, R. Gilbert, and T. N. Kaye. 2011. Management Strategies for Invasive Plants in Pacific Northwest Prairies, Savannas, and Oak Woodlands. Northwest Science 85:329–351.

Diaz, S., and S. Harris. 2024. Status of the Fender's blue butterfly: 2023 annual report. Institute for Applied Ecology, Corvallis, Oregon.

Fields, J., D. Giles, and A. Esterson. 2022. Habitat restoration and monitoring for Kincaid's lupine at Fir Butte: 2021 annual report. Institute for Applied Ecology, Corvallis, OR.

Kaye, T. N. 1999. Obligate insect pollination of a rare plant, *Lupinus sulphureus* ssp. *kincaidii*. Northwest Science 73:50–52.

Milligan, G., E. S. Cox, J. G. Alday, V. M. Santana, H. A. McAllister, R. J. Pakeman, M. G. Le Duc, and R. H. Marrs. 2016. The effectiveness of old and new strategies for the long-term control of *Pteridium aquilinum* , an 8-year test. Weed Research 56:247–257.

Reed, P. B., and L. M. Hallett. 2023. Spatiotemporal patterns of rising annual plant abundance in grasslands of the Willamette Valley, Oregon (USA). Landscape Ecology 38:2885–2898.

Reed, P. B., L. Pfeifer-Meister, B. A. Roy, B. R. Johnson, G. T. Bailes, A. A. Nelson, and S. D. Bridgham. 2021. Introduced annuals mediate climate-driven community change in Mediterranean prairies of the Pacific Northwest, USA. Diversity and Distributions 27:2584–2595.

Reed, P., D. Giles, A. Esterson, and Harris, Scott. 2023. Habitat restoration and monitoring for Kincaid's lupine at Fir Butte: 2022 annual report. Institute for Applied Ecology, Corvallis, OR.

Thorpe, A. S. 2011. Kincaid's lupine (*Lupinus oreganus*) and community monitoring at Fir Butte. Institute for Applied Ecology, Corvallis, Oregon, USA.

U.S. Fish & Wildlife Service. 2015. Final PROJECTS Biological Opinion. Oregon Fish and Wildlife Office, US Fish and Wildlife Service, Portland, OR, USA.

U.S. Fish and Wildlife Service. 2010. Recovery plan for the prairie species of western Oregon and southwestern Washington. U.S. Fish and Wildlife Service, Portland, OR, USA.

U.S. Fish and Wildlife Service. 2014. Biological opinion for the Resource Management Plan for the West Eugene Wetlands in Lane County, Oregon. U.S. Fish and Wildlife Service, Portland, OR, USA.

APPENDICES

Appendix 1. Fir Butte management actions (2008-2022)

Year	Date	Activity	Personnel*	Notes
2008	June-July	Weed control	Land steward	Pull tansy ragwort (*Senecio jacobaea*)
2008	June-July	Weed control	Land steward	Clip seed heads on tall oatgrass (*Arrhenatherum elatius*)
2008	June-July	Weed control	Land steward	Shade cloth on meadow knapweed (*Centaurea pratensis*) at N end, S end, and around E small shade cloth patch
2008	June-July	Weed control	Land steward	Pull meadow knapweed in N end, S end, and around E small shade cloth patch
2008	June-July	Weed control	NWYC	Pull Scotch broom (*Cytisus scoparius*), tansy ragwort, and tall oatgrass
2008	June-July	Weed control	NWYC	Pull meadow knapweed in N end, S end, and around E small shade cloth patch
2008	April-June	Weed control	Land steward	Cut Himalayan blackberry (*Rubus bifrons*) along fenceline and shade cloth
2008	April-June	Weed control	Land steward	Cut bracken fern (*Pteridium aquilinum*)
2008	June-July	Woody species control	Land steward	Cut Ponderosa pine (*Pinus ponderosa*) in 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
2009	June-July	Weed control	Youth crew	Clip seed heads from tall oatgrass
2009		Weed control	Monitoring staff	Pull Scotch broom, tansy ragwort, tall oatgrass
2009		Weed control	Monitoring staff	Shade cloth, cut meadow knapweed and Himalayan blackberry
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	Weed control	Monitoring crew	Pull Scotch broom in South end
2010	April-July	Weed control	Monitoring crew	Pull bracken fern

Year	Date	Activity	Personnel*	Notes
2010	June-July	Weed control	Monitoring crew	Pull purple-anther pepper weed
2010		Weed control	Youth crew	Pull Scotch broom, tansy ragwort, tall oatgrass
2010		Weed control	Youth crew	Pull Scotch broom, tansy ragwort, tall oatgrass
2011	April-June	Shade cloth repair	LGYC	Eastern border
2011	April-June	Weed control	LGYC	Pull bracken fern
2011	June-July	Woody species control	LGYC	Cut woody species
2011	June-July	Weed control	LGYC	Pull tansy ragwort
2011	August-October	Weed control	LGYC	Pull tansy ragwort
2011	April-June	Weed control	NWYC	Pull bracken fern
2011	August-October	Woody species control	BLM contractor	Masticate Himalayan blackberry
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 shade cloth and solarization	LGYC	E border of site
2012	April-June	Weed control	LGYC	Pull Scotch broom, tansy ragwort, tall oatgrass
2012	June-July	Weed control	LGYC	Pull Scotch broom, tansy ragwort, tall oatgrass
2012	June-July	Apply shade cloth	IAE/LGYC	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
2012	October	Plant nectar species	IAE/LGYC	Shade cloth and solarization area on E border of site
2013	17-Apr	Marking of weeds site wide	IAE	Systematically marked locations of *Cirsium vulgare*, *Cytisus scoparius, Centaurea 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.

Year	Date	Activity	Personnel*	Notes
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 shade cloth/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 shade cloth areas	IAE	Took pre-treatment data on shade cloth areas to be placed with youth crew the next week
2013	10-May	Weed control	IAE	Weed whacked all new shade cloth plots in preparation for youth crew. Weed whacked 2m wide perimeter around all shade cloth plots. Tilled 3 of the 4 plots that are to receive solarization next week.
2013	14, 15, 22-May	Weed control	IAE/LGYC	Shade cloth/solarization installation.
2013	19-Jun	Weed control	IAE/ NWYC crew of 6	Mow tall oatgrass with string trimmer: 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. Hand weeded solarization plots.
2013	19-Jun	Hand weeding solarization plots	IAE/ NWYC (crew of 6)	Hand weeded starting in SW corner of shade cloth/solarization experiment area. Attempted to be thorough but impractical with this density of *Agrostis capillaris* and *Rumex acetosella* colonization.
2013	10-Jul	Weed control	IAE	Hand weeded in shade cloth/ 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.
2013	16-Sep	Weed control	IAE	In large shade cloth/solarization experiment plot, dug out all visible Purple anther pepper weed (*Lepidium heterophyllum*) plants that had set seed this year. Small plants in leaf were generally not removed. Lots of dry seed on the plants.

Year	Date	Activity	Personnel*	Notes
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 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	Replaced T-posts in middle of property. Started at north end and replaced all green transect T-posts. Put metal scratch tag on concrete markers that says 'transect'. For 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	Weed control	IAE	Clipped seed heads on meadow knapweed along north border and east of big shade cloth area.
2013	18-Sep	Wooden post removal	IAE	Removed 2 wooden posts with signs along E edge and placed on nearby shade cloth plots.
2013	18-Sep	Large shade cloth alteration	IAE	Lifted east edge of big shade cloth 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, shade cloth removal, weed whacking around plots	IAE	Raked four solarization plots to refill trenches. Weed whacked around all solarization/shade cloth plots because mower will not be able to mow close to plots/stakes. Removed shade cloth on plots 1a and on small lepidium shade cloth plot. Tall oatgrass in areas that were weed whacked on 5/10 flowered 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".
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

Year	Date	Activity	Personnel*	Notes
2014	5, 6-Jun	Weed control	IAE/ 4 people from Walama	Hand mowed tall oatgrass at 6" throughout site. Where growing concurrently with Kincaid's lupine (*Lupinus oreganus*), mowed above top of raceme. At Cheryl Schultz' request did not mow L shape patch in SW corner.
2014	6-Jun	Monitoring	IAE	Monitored shade cloth/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
2014	17, 18-Jun	Hand weeding bracken fern	IAE/ 12 from NWYC	Weeded 200 feet west of plot 2a around Kincaid's lupine
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	Re-mowed 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
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 shade cloth/solarization test plots
2015	13-May	Removed weeds	IAE	Removed Lepidium from plot 6, weeded invasive grasses from nectar islands

Year	Date	Activity	Personnel*	Notes
2015	26, 27-May	Hand mow tall oatgrass	IAE/ Walama Restoration	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.
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
2015	9-Nov	Planting	IAE/ LGYC	Planted plugs and bulbs in plot 4b
2015	10-Nov	Planting	IAE/ LGYC/ AmeriCorps	Planted plugs, bulbs, and runners in plots 4b, 5b and 2b, moved shade cloth 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	Planted strawberry runners in plots 1b, 5b, and 2b weeded *Agrostis* from 1a
2015	8-Dec	Seeding	IAE	Over seeded plots 1a, 1b, 2b, 4b, 5a, and 5b
2016	31-Mar	Herbicide application	IAE	Applied Fusillade herbicide to four experimental plots to test non-target impact of using Fusillade to manage prairie harboring Fender's blue butterfly
2016	19, 20-April	Hand weeding	IAE/LGYC	Hand-weeded meadow knapweed, purpleanther field pepper weed (*Lepidium heterophyllum*), bull thistle (*Cirsium vulgare*), tansy ragwort in northern portion of site; removed hairy cat's ear (*Hypochaeris* spp.), sheep sorrel (*Rumex acetosella*), and bentgrass (*Agrostis* spp.) from nectar islands
2016	6-May	Survey for Fender's blue butterfly	IAE/ 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.

Year	Date	Activity	Personnel*	Notes
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/ LGYC	Hand weeded meadow knapweed, mainly in the NW corner
2016	17-Aug	Hand weeding	IAE/ BLM	Removed Himalayan blackberry from edges of nectar islands, weeded nectar islands
2016	22-Aug	Burn break prep	IAE/ BLM	Mowed edges of Schultz research plots to prepare for prescribed burn.
2016	22-Aug	Shade cloth	IAE/ BLM	Replaced shade cloth 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/ LGYC/ AmeriCorps/ volunteer	Planted bulbs and bare root lomatium in plots 1c, 2c, 4c & 5c
2016	21-Nov	Planting	IAE/ BLM/ LGYC/ AmeriCorps/ volunteer	Planted plugs and bulbs in plots 4c, 1c, 2c, and 5c
2016	29-Nov	Seeding	IAE	Over seeded plots 1a, 1b, 1c, 2a, 2b, 2c, 3a, 3b, 4a, 4b, 4c, 5a,5b, 5c
2017	23-Mar	Herbicide application	Habitat Restoration LLC	Applied Fusillade herbicide to four experimental plots to test non-target impact of using Fusillade 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
2017	13-Jul	Weed removal	BLM/ LGYC	Removed meadow knapweed inflorescences
2017	6-Jun	Hand mow tall oatgrass	IA/ 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/ BLM	Cleared and prepared shade cloth for nectar species planting

Year	Date	Activity	Personnel*	Notes
2017		Fire break prep	Contractor	Mowed fire brake around burn zone
2017	13-Sep	Fire break prep	IAE/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/ BLM	Burned 1710 holes in shade cloth and seeded with native mix
2017	24-Oct	Seeding	IAE/ BLM	Seeded wet prairie with native mix
2017	26-Oct	Seeding	IAE/ BLM	Seeded upland with native mix
2017	8-Nov	Planting	IAE/ BLM/ LGYC	Planted 400 Kincaid's lupine plugs at Hansen
2017	14-Nov	Planting	BLM/ LGYC	Planted approximately 1200 *Fragaria virginiana* runners
2017	15-Nov	Planting	IAE/ BLM/LGYC	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/ BLM	Burned holes in weed barrier
2017	21-Nov	Planting	IAE/ 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 Fusillade herbicide to four experimental plots to test non-target impacts of using Fusillade 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
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

Year	Date	Activity	Personnel*	Notes
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
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 nectar island 8a.
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)	Spot-sprayed glyphosate over 1.5 acres in SE corner; flagged lupine areas were not sprayed
2019	4/23	Herbicide application	IAE/ Contractor (IRM)	Spot-sprayed 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
2019	5/24	Weed control	IAE/ BLM	Mowed tall oatgrass

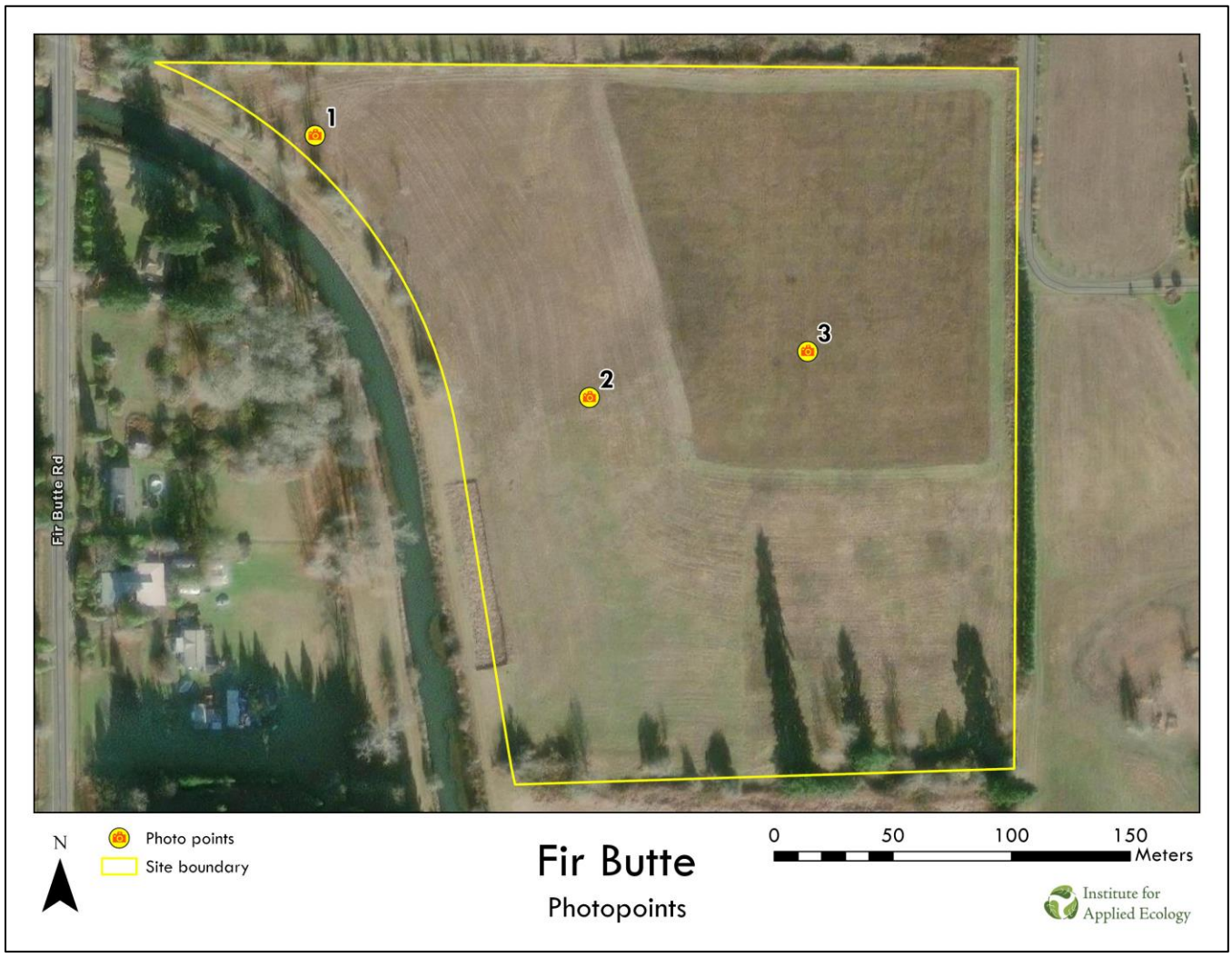
Year	Date	Activity	Personnel*	Notes
2019	6/11	Weed control	IAE	Spot sprayed meadow knapweed with 1.5% solution of glyphosate
2019	7/24	Weed control	IAE	Hand pulled and spot sprayed meadow knapweed
2019	7/20	Site preparation	IAE	Removed pin flags from SE corner to prepare for mowing
2019	9/12	Weed control	IAE/ Contractor (NTS)	Spot sprayed blackberry, hawthorn (*Crataegus monogyna*), and rose (*Rosa* sp.)
2019	11/5	Site preparation	BLM/ LGYC	Removed weed cloth from nectar island 6d
2020	1/30	Weed control	IAE/BLM/Contractor (IRM)	Spot-sprayed Rodeo/Nu-Film-IR with backpacks over 3 acres in SE corner and less than one acre in nectar island 8a. Targeted all vegetation outside lupine patches.
2020	4/28	Weed control	IAE/BLM	Spot spray of meadow knapweed throughout site with Rodeo/NuFilm-IR
2020	5/5	Site visit	IAE	Site visit by Rebecca Currin and Ian Silvernail.
2020	6/23	Weed control	IAE/BLM/Contractor (IRM)	Spot-sprayed Rodeo/Nu-Film-IR with backpacks over 3 acres in SE corner and less than one acre in nectar island 8a. Target was all vegetation outside lupine patches.
2020	7/10	Weed control	IAE/BLM	Spot spray with Rodeo/Nu-Film-IR of areas missed during 6/23 spray.
2020	7/22	Site visit	IAE/BLM	Site visit by Sally Villegas-Moore, Julia Fields, Rebecca Currin, and Ian Silvernail.
2020	7/24	Weed control	IAE/BLM	Complete spot spray with Rodeo/Nu-Film-IR of areas missed during 6/23 spray that was initiated on 7/10. Hand pulled tansy ragwort.
2020	8/5	Site visit	IAE/BLM	Site visit to assess conditions.
2020	August	Weed control	BLM/ LGYC	Hand pull meadow knapweed.
2020	9/29	Site visit	IAE/BLM	Site visit, lupine senesced.
2020	10/1	Woody species control	IAE/BLM/Contractor (NTS)	Spot spray blackberry, hawthorn and rose.
2020	11/20	Site preparation	IAE/BLM/Contractor (IRM)	Broadcast glyphosate to 3.5 ac in SE corner and nectar island 8a.
2020	12/22	Site visit	IAE	Site visit to assess herbicide efficacy.
2021	1/14	Weed control	IAE	Spot sprayed SE corner with glyphosate.
2021	3/16	Weed control	IAE	Site visit to assess conditions. Flagged lupine in SE corner.
2021	4/14	Weed control	IAE	Spot sprayed meadow knapweed and SE corner.

Year	Date	Activity	Personnel*	Notes
2021	5/3	Weed control	IAE	Spot sprayed meadow knapweed, SE corner, and nectar island 8a.
2021	5/13	Site visit	IAE	Site visit to assess herbicide treatment and take photopoints.
2021	5/26	Site visit	IAE	Finished flagging lupine in SE corner.
2021	6/18	Weed control	IAE	Spot sprayed SE corner and nectar island 8a.
2021	7/12	Site visit	IAE/BLM	Site visit to discuss treatment options and seeding.
2021	8/5	Mapping	IAE	Mapped tall oatgrass population.
2021	8/18	Weed control	IAE	Spot sprayed bracken fern and hand pulled meadow knapweed.
2021	9/14	Woody species control	IAE/Contractor (IRM)	Treated woody plants throughout meadow.
2021	9/29	Site visit	IAE/USACE	Site visit to discuss use of seed drill.
2021	10/4	Weed control	IAE	Broadcast glyphosate to SE corner and nectar island 8a.
2021	10/14	Seeding	IAE/BLM	Seeded SE corner and nectar island 8a with dew drop drill borrowed from USACE.
2022	2/25	Site visit	IAE	Site visit to assess conditions.
2022	3/4	Planting	IAE, BLM	Planted approximately 1000 *Sidalcea malviflora* plants in nectar island 8a, donated by Heritage Seedlings & Liners, Inc.
2022	5/16	Weed control	IAE	Spot sprayed meadow knapweed across entire site with glyphosate.
2022	7/25	Site visit	IAE	Took photo points.
		Weed control	IAE	Pulled Scotch broom from SE corner.
2022	8/8	Weed control	IAE, BLM	Pulled knapweed, tansy ragwort, bull thistle, and Scotch broom from entire site.
2022	8/31	Woody species control	IAE	Spot sprayed woody species throughout northern half of site with triclopyr.
2022	9/2	Site maintenance	BLM/contractor	Mowed entire site except six acre burn unit in NE corner.
2022	9/21	Site visit	IAE, BLM	Site visit to discuss fall 2022 plans, upcoming prescribed burn, and seed mix. Checked on mowed areas and efficacy of triclopyr treatment.
2022	10/4	Prescribed burn	BLM	Burned five acre unit in NE corner.
2022	11/15	Weed control	IAE/Habitat Restoration LLC	Broadcast glyphosate over five acre burn unit in NE corner.

* 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. Fir Butte photopoints

Photos taken on May 19, 2023.



Photopoint 1

North

East

South

West

Photopoint 2

North

East

South

West

Photopoint 3

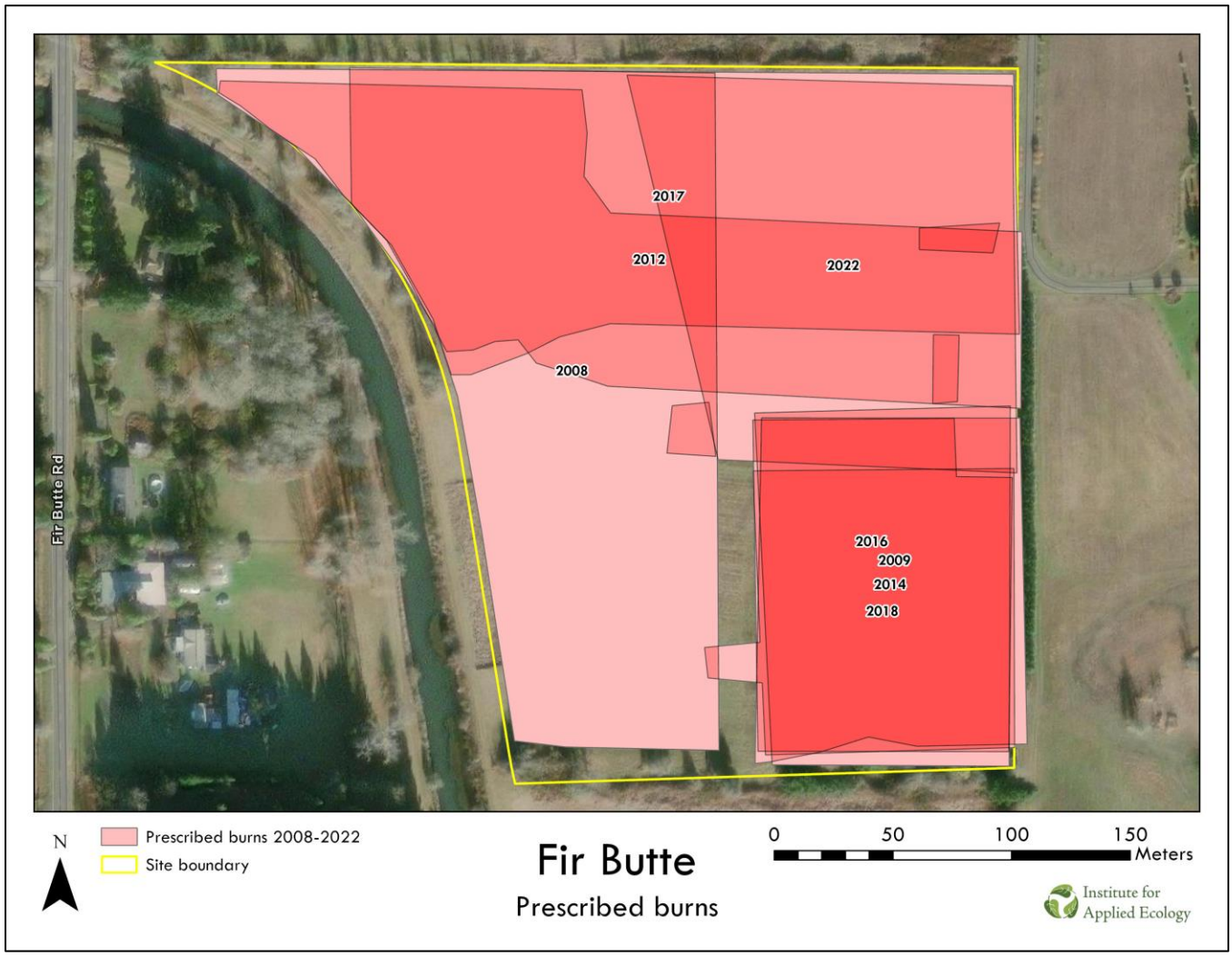
North

East

South

West

Appendix 3. Fir Butte prescribed burns from 2008-2018



Appendix 4. Nectar islands map

Appendix 5. Nectar islands history

Plot	Size	Year established	Treatment type	Year planted
1a	8m x 10m	2012	Shade cloth	2014 (plants), 2015 (seed), 2016 (seed)
1b	8m x 10m	2014	Shade cloth	2015 (seed), 2016 (seed)
1c	8m x 10m	2015	Shade cloth	2016 (plants and seed)
2a	8m x 10m	2012	Shade cloth	2013 (plants and seed), 2016 (seed)
2b	8m x 10m	2013	Shade cloth	2015 (plants and seed) 2016 (seed)
2c	8m x 10m	2015	Shade cloth	2016 (plants and seed)
3a	8m x 10m	2012	Shade cloth	2013 (plants and seed), 2016 (seed)
3b	8m x 10m	2013	Shade cloth	2014 (plants), 2015 (seed), 2016 (seed)
4a	8m x 10m	2012	Shade cloth	2014 (plants), 2015 (seed), 2016 (seed)
4b	8m x 10m	2013	Shade cloth	2015 (plants and seed), 2016 (seed)
4c	8m x 10m	2015	Shade cloth	2016 (plants and seed)
5a	8m x 10m	2012	Shade cloth	2014 (plants and seed), 2016 (seed)
5b	8m x 10m	2014	Shade cloth	2015 (plants and seed), 2016 (seed)
5c	8m x 10m	2015	Shade cloth	2016 (plants and seed)
6d	15m x 25m	2017	Solarization, shade cloth	2017 (plants and seed)
4e (small)	9m x 8m	2018	Solarization, shade cloth	2018 (seed)
7e	6m x 20m	2018	Solarization, shade cloth	2018 (seed)
4e (big)	20m x 13m	2018	Solarization, shade cloth	2018 (seed)
8a	0.25 acres	2018	Prescribed burn and chemical fallow	2021 (seed), 2022 (plants)
SE corner	3 acres	2018	Prescribed burn and chemical fallow	2021 (seed)

Appendix 6. Nectar islands plant materials

Nectar plots seeded and planted from 2014-2022.

Year	Nectar plot	
	Seeded	**Planted**
2014	1a, 3b, 5a	1a, 3b, 5a
2015	1b, 2b, 4b, 5b	1b, 2b, 4b, 5b
2016	1a, 1b, 1c, 2a, 2b, 2c, 3a, 3b, 4a, 4b, 4c, 5a, 5b, 5c	1c, 2c, 4c, 5c
2017	6d	6d
2018	1a, 1b, 1c, 2a, 2b, 2c, 4a, 4b, 4c, 5a, 5b, 4e (small), 7e	-
2021	8a, SE corner	-
2022	-	8a

Species planted in nectar plots from 2014-2022.

Scientific name	Common name	Form	Quantity				
			2014	**2015**	**2016**	**2017**	**2022**
Allium amplectens	narrowleaf onion	bulbs	1,650	700	1,500	-	-
		plugs	-	-	-	300	-
Camassia leichtlinii	large camas	bulbs	10 trays	-	-	-	-
		plugs	-	-	-	300	-
Eriophyllum lanatum	Oregon sunshine	1'x2' Flats	186	-	-	-	-
		band pots	-	60	-	-	-
Eriophyllum lanatum	Oregon sunshine	band pots	-	-	-	250	-
Festuca roemeri	Roemer's fescue	medium plugs	800	2,448	400	-	-
Fragaria virginiana	wild strawberry	ramets	-	1,000	-	-	-
Iris tenax	Oregon iris	4" pots	-	40	-	-	-
Lomatium nudicaule	barestem biscuitroot	bare root	699	-	2,600	-	-
Luzula comosa	Pacific woodrush	medium plugs	273	-	800	-	-
Sidalcea malviflora ssp. virgata	dwarf checkermallow	medium plugs	1,080	2,560	1,600	-	1,000
		band pots	-	-	-	350	-
Sisyrinchium idahoense	Idaho blue-eyed grass	4" pots	-	80	-	-	-
Triteleia hyacinthina	white brodiaea	bulbs	1 tray	-	-	-	-
Zigadenus venenosus	death camas	bulbs	800	500	-	-	-

Seed broadcast in nectar plots from 2014-2021.

Scientific name	Common name	Seed (lbs)					
		2014	2015	2016	2017	2018	2021
Achillea millefolium	common yarrow	0.06	0.09	0.20	0.20	0.10	0.17
Allium amplectens	narrowleaf onion	-	-	-	-	1.20	1.39
Camassia leichtlinii var. *suksdorfii*	large camas	1.31	1.61	1.59	1.59	5.01	-
Camassia quamash	Common camas	-	-	-	-	-	4.88
Carex tumulicola	Splitawn sedge	-	-	-	-	-	1.88
Clarkia purpurea ssp. *quadrivulnera*	farewell-to-spring	0.02	0.02	0.06	0.06	-	0.26
Collomia grandiflora	large-flowered collomia	-	-	-	-	-	3.01
Danthonia californica	California oatgrass	-	-	-	-	-	4.36
Epilobium densiflorum	denseflower willowherb	0.05	0.07	0.09	0.09	-	0.43
Eriophyllum lanatum	Oregon sunshine	0.07	0.23	0.17	0.17	0.81	0.42
Festuca roemeri	Roemer's fescue	0.35	0.52	0.84	0.84	-	1.22
Hordeum brachyantherum	meadow barley	-	-	-	-	-	3.25
Iris tenax	toughleaf iris	-	-	-	-	-	7.95
Linanthus bicolor	true babystars	0.02	0.02	0.02	0.02	-	0.15
Lomatium nudicaule	barestem biscuitroot	-	0.22	0.19	0.20	1.21	6.17
Lupinus oreganus	Kincaid's lupine	-	-	-	-	-	6.00
Luzula comosa	Pacific woodrush	0.09	-	-	-	0.12	0.52
Madia elegans	Showy tarweed	-	-	-	-	-	1.14
Microseris laciniata	cutleaf silverpuffs	0.10	0.12	0.17	0.17	0.29	1.54
Nemophila menziesii var. *atomaria*	baby blue eyes	-	0.06	0.05	0.11	-	-
Perideridia oregana	Oregon yampah	-	-	-	-	-	0.77
Plectritis congesta	shortspur seablush	0.07	0.51	0.21	0.21	0.20	0.46
Potentilla gracilis var. *gracilis*	slender cinquefoil	0.03	0.40	0.07	0.07	-	0.26
Prunella vulgaris var. *lanceolata*	self-heal	0.16	0.18	0.31	0.31	0.34	0.91
Ranunculus occidentalis	Western buttercup	-	-	-	-	0.44	1.83
Sidalcea malviflora ssp. *virgata*	dwarf checkermallow	0.49	0.83	0.83	0.83	4.00	4.59
Sisyrinchium idahoense	Idaho blue-eyed grass	-	-	-	-	0.22	2.01
Wyethia angustifolia	narrowleaf mule's ears	0.66	0.75	0.48	0.48	-	3.67
Total		**3.48**	**5.63**	**5.28**	**5.35**	**13.94**	**59.24**

Appendix 7. Kincaid's lupine monitoring results

Foliar cover, number of leaves, number of mature racemes, and racemes/m^2 of Kincaid's lupine at Fir Butte from 1998-present. Data was not collected every year.

Year	Estimated # of leaves		Estimated foliar cover (m^2)		Estimated # of mature racemes		Estimated # racemes/m^2 lupine cover
	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	-	-	-	-	-	-	-
2020	-	-	5,931	±1,515	196,011	±61,004	33
2021	-	-	4,678	±1,214	108,279	±29,643	23
2022	-	-	7,115	±1,508	151,900	±37,746	27
2023	-	-	6,701	± 2,739	148133	±60,301	22