

Upper Oak Basin Kincaid's lupine and Hitchcock's blue-eyed grass monitoring and restoration: 2021 Annual Report



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Report to the Bureau of Land Management, Upper Willamette
Resource Area: Northwest Oregon District, L21AC10022,
L21AC10456, L20AC00228, and L21AC10117

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PREFACE

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



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Cover photographs: Oak Basin, Meadow A. Photo taken by Celeste Lebo, May 5, 2021.
All photos in this document are taken by IAE staff, unless specified otherwise.

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1. EXECUTIVE SUMMARY

This report documents habitat restoration and vegetation monitoring activities conducted by the Institute for Applied Ecology (IAE) in partnership with the Bureau of Land Management's (BLM) Upper Willamette Field Office (UWFO), Northwest Oregon District, at Oak Basin, a complex of upland meadows. Oak Basin is home to Kincaid's lupine (*Lupinus oreganus*), a federally threatened species, and Hitchcock's blue-eyed grass (*Sisyrinchium hitchcockii*), a federal Species of Concern. Kincaid's lupine serves as the primary larval host plant for the endangered Fender's blue butterfly (*Icaricia icarioides fenderi*). The small population of Fender's blue butterfly at Oak Basin has been on the decline since 2015, and only 36 individuals were documented in 2021 at Oak Basin on BLM-administered land, with two additional observations on adjacent private land. All three species are endemic to western Oregon prairies.

Management treatments

Restoration activities conducted in 2021 included mowing Kincaid's lupine patches to reduce invasive perennial grass and shrub cover; removal and limbing of conifers between meadow corridors to increase meadow connectivity and reduce woody encroachment around Kincaid's lupine patches; hand-pulling or grubbing of invasive plants, including Himalayan blackberry (*Rubus armeniacus*), Scotch broom (*Cytisus scoparius*), and Italian plumeless thistle (*Carduus pycnocephalus*); implementing a combination of herbicide and seeding treatments in experimental plots; and planting 495 plugs (containerized seedlings) in Meadow A.

Kincaid's lupine

In 2021, total Kincaid's lupine foliar cover at Oak Basin was 164.9 m², the third highest foliar cover documented since monitoring began in 2006 and generally continuing the positive trend that started in 2016. In 2021, the count of mature racemes was 2,472, a decrease from 2020. Since the initiation of more active management practices in 2016, all meadows have shown a positive trend in foliar cover and count of mature racemes. Other lupine-occupied sites monitored by IAE also had lower raceme counts than in the previous year; the decrease may be related to climatic factors and relatively low precipitation during the spring growing season.

Hitchcock's blue-eyed grass

The number of Hitchcock's blue-eyed grass individuals and reproductive stems at Oak Basin's Meadow C increased from 2016 through 2020; however, in 2021, numbers decreased to the second lowest recorded since monitoring began with only 33 flowering stems and 21 reproductive plants (range of flowering stems from 19 to 225 from 2012 through 2021; range of reproductive plants 12 to 84). Hitchcock's blue-eyed grass and Kincaid's lupine have followed roughly parallel trajectories in population size at Oak Basin.

Recommendations

Based on effects of management actions and the importance of the Oak Basin site for reaching recovery goals for the Fender's blue butterfly and Kincaid's lupine, continued management of non-native species, particularly introduced perennial and annual graminoids, is recommended. Activities in 2022 should include continued control of non-native plants. We recommend that the meadows and, especially, the corridors between meadows be treated for non-native plants using all available tools (e.g., herbicide, fire, mechanical treatment), followed by the seeding and planting of treated areas with a mix of native nectar species and native perennial grasses.

Oak Basin Kincaid's lupine and Hitchcock's blue-eyed grass Monitoring and Restoration: 2021 Annual Report

2. INTRODUCTION

This report documents habitat restoration and rare plant and community monitoring activities conducted by the Institute for Applied Ecology (IAE) at Oak Basin in 2021. Oak Basin, managed by the Northwest Oregon BLM (Bureau of Land Management) District's Upper Willamette Field Office, is about six miles southeast of Brownsville, Oregon. The site includes upland prairie and oak (*Quercus garryana*), maple (*Acer macrophyllum*), and Douglas-fir (*Pseudotsuga menziesii*) woodlands. Oak Basin supports the largest known population of Kincaid's lupine (*Lupinus oreganus*; Figure 1) in the Upper Willamette Field Office's management area and is home to a population of the endangered Fender's blue butterfly (*Icaricia icarioides fenderi*, Figure 1). The Oak Basin Fender's blue butterfly population is relatively small, with only 38 butterflies documented in 2021, and remains vulnerable to complete sub-population collapse and extirpation (Diaz 2021).

Vegetation monitoring by IAE at Oak Basin is focused on documenting the size and reproduction of the Kincaid's lupine population and assessing habitat quality. This information is used to determine the effectiveness of restoration treatments at the site and to document long-term population trends in support of meeting recovery goals as outlined in the Recovery Plan for the Prairie Species of Western Oregon and Southwestern Washington (Recovery Plan, U.S. Fish and Wildlife Service, 2010). In addition to monitoring Kincaid's lupine, IAE also monitors a small population of the rare Hitchcock's blue-eyed grass (*Sisyrinchium hitchcockii*) to document population trends.



Figure 1. Fender's blue butterfly (*Icaricia icarioides fenderi*, top) and Kincaid's lupine (*Lupinus oreganus*, bottom). Photos taken on May 5, 2021 in Meadow B.

Species status and information

Kincaid's lupine is a member of the legume family (Fabaceae). It is an herbaceous perennial that reproduces by seed. Plants form clumps of basal leaves and eventually produce one or more flowering stems. The species also spreads vegetatively, though it is unknown to what extent vegetative growth may result in the formation of physiologically distinct clones (Severns et al. 2011). Kincaid's lupine requires insects for successful fertilization and seed formation (Kaye 1999). It is found in native prairie remnants in the Willamette Valley and southwestern Washington and in forest openings in Douglas County, Oregon. Because Kincaid's lupine serves as the larval host for the federally endangered Fender's blue butterfly (Oregon Biodiversity Information Center 2016), conservation of Kincaid's lupine populations is the primary goal for the protection of both species. Kincaid's lupine is listed by the Oregon Department of Agriculture and the U.S. Fish and Wildlife Service (USFWS) as a threatened species (Oregon Biodiversity Information Center 2016).

Hitchcock's blue-eyed grass is a rhizomatous perennial forb in the Iris family (Iridaceae; Figure 2). The species reproduces by seed and by clonal vegetative growth. It is listed as a federal Species of Concern by the U.S. Fish and Wildlife Service (Oregon Biodiversity Information Center 2016) and is a Bureau Sensitive Species for the BLM.



Figure 2. Hitchcock's blue-eyed grass (*Sisyrinchium hitchcockii*): (a) long and narrow leaves with parallel veins that are mostly basal; (b) 3-chambered capsules up to 6 mm long containing black seeds; and (c) flowers with blue to bluish-purple tepals with a faint (or absent) yellow "eye" in the center.

Oak Basin has been identified as a potential "functioning network" for the Eugene East Recovery Zone to meet the down-listing goals for Fender's blue butterfly. To down-list the species, each recovery zone must have one functioning network (a metapopulation with several interacting subpopulations, as defined in the recovery plan) with a minimum count of 200 butterflies, distributed among 3 subpopulations, for at least 10 years. And, in addition to this network, there must be a second functioning network or two independent populations with butterflies present each year in the recovery zone. The site contributes to the recovery of Kincaid's lupine since the population currently meets the minimum local foliar cover of 100 m² needed for the site to count towards recovery (USFWS 2010) in Meadow A, one of the three main meadows at the site. Additionally, large patches of Kincaid's lupine occur on the adjacent,

privately owned Oak Basin Tree Farm that is currently being restored through a cooperative agreement between private landowners, The Nature Conservancy, Oregon Department of Fish and Wildlife, and U.S. Fish and Wildlife's Partners for Fish and Wildlife Program.

Fender's blue butterfly life cycle

Fender's blue butterflies become mature adults in May and June at which time they fly, consume nectar, and mate. The females oviposit their eggs on the underside of Kincaid's lupine leaves. Eggs are identifiable as small (0.5–1.0 mm) white spheres. The eggs hatch in a few weeks; hatched eggs resemble unhatched eggs except that they are burst in the center, making them look like little white "donuts." The larvae subsequently feed on Kincaid's lupine leaves until late June or early July, at which time they crawl under nearby vegetation and plant litter and enter diapause. They remain in a dormant state until February or early March when they then begin feeding again on the newly emerging Kincaid's lupine leaves. Near the end of April, they pupate and reemerge as butterflies (Schultz and Crone 1998).

3. GOALS AND OBJECTIVES

Monitoring

The objectives of the monitoring portion of this project are to track the size and reproductive status of the population of Kincaid's lupine at Oak Basin and examine overall Kincaid's lupine and Fender's blue butterfly habitat quality over time. Specifically, we aim to link these data with habitat restoration activities occurring on-site, conducted and facilitated by IAE, and to document population size and trends to ensure that the population remains stable or increases, with area of foliar cover being maintained at or above the minimum targets as laid out in the Recovery Plan (USFWS 2010). A second objective is to assess the status of the Hitchcock's blue-eyed grass population and to help guide restoration activities at the site. The following is a detailed list of recovery goals outlined in the Recovery plan:

- Increase the Fender's blue butterfly population to a minimum of 200 individuals, with the population remaining stable or increasing over a period of 10 years.
- Maintain Kincaid's lupine foliar cover at a minimum area of 100m² in each meadow, with the population remaining stable or increasing over a period of 15 years. Ideally, this population will increase in size beyond the minimum area necessary to count towards recovery. The Oak Basin site is within the Eugene East Recovery Zone. The zone has a target of supporting at least two populations with a total foliar cover of 5,000 m².
- Kincaid's lupine populations must show evidence of reproduction by seed set or by the presence of seedlings.
- Increase cover of native prairie species to at least 50%.
- Decrease woody species cover to less than 15%.
- Increase prairie species diversity so that there are at least 10 native prairie species, including seven or more forbs and at least one native bunchgrass (within a representative 25 m² area).
- Decrease non-native vegetation so that no single non-native plant has more than 50% cover.
- Increase nectar species abundance at the site. Sufficient abundance of nectar species should be available at the site throughout the Fender's blue butterfly flight season, with sufficient abundance of nectar (20 mg nectar sugar/m²) and at least five native nectar species present (within a 25 m² area).

Habitat restoration

The goals of restoration actions at Oak Basin are to maintain and improve prairie habitat in support of Kincaid's lupine and its associated Fender's blue butterfly populations. The four primary objectives of this project are to:

- maintain and improve quality prairie habitat by removing non-native invasive plants;
- prevent encroachment of woody species into the prairie;
- increase diversity and the areal extent of the native plant community; and
- improve connectivity between meadows at Oak Basin.

4. METHODS

Monitoring methods

Habitat quality

In 2021, we continued habitat monitoring efforts begun in 2020 to collect data that are directly applicable to the habitat quality criteria measurements as outlined in the Recovery Plan (USFWS 2010). Standard relevé plots (5m x 5m) were established in each meadow, two in Meadow A and one each in Meadows B and C. All species within each plot were recorded, and a richness estimate for each 25m² area, as well as the proportions of native and non-native species and plant management groups, was calculated.

Restoration experiment

In addition to the relevé plots, in 2020 a new experimental restoration project was installed to assess the efficacy of utilizing various combinations of mowing, fire, application of glyphosate, and seeding over time (one, two, and four years after treatment). Plots were first sampled in 2021. Future sampling will take place in 2022 and 2024. Two different treatment combinations, hereafter referred to as treatments, are being evaluated that include the following components: mowing (M) in the spring to prevent seed set and to reduce stored reserves of non-native perennial grasses; flame weeding (B) in the fall to reduce thatch build-up and prep the site for seeding; a post-burn spot application of 1.5% glyphosate (G) to reduce the abundance of non-native herbaceous perennials; and the application of seed (S). Mowing height will be 3-10 cm and the biomass will be left in place. In addition to the experimental treatments, a "no treatment" regime was included as a control.

A total of 10 experimental plots (10m x 30 m) were established in occupied Kincaid's lupine habitat in three BLM meadows: four in Meadow A and three in each of Meadows B and C. Plots were divided into three 100m² (10m x 10m) subplots: control, GBGS, and MBGS. The control subplot was further subdivided into two 10m x 5m plots, one that will be seeded using the same mix as the treated subplots and one that will be left unseeded (Figure 3).

Data are collected from four 1m² quadrats randomly placed within each of the subplots in June. Percent cover is visually estimated to the nearest 1% for all vascular species. Ground cover classes will be divided into the following: basal vegetation, bare ground, rock, moss, and thatch (defined as non-living vegetative matter). Photos of each subplot are taken from the south-central edge of the plot before sampling the quadrats.

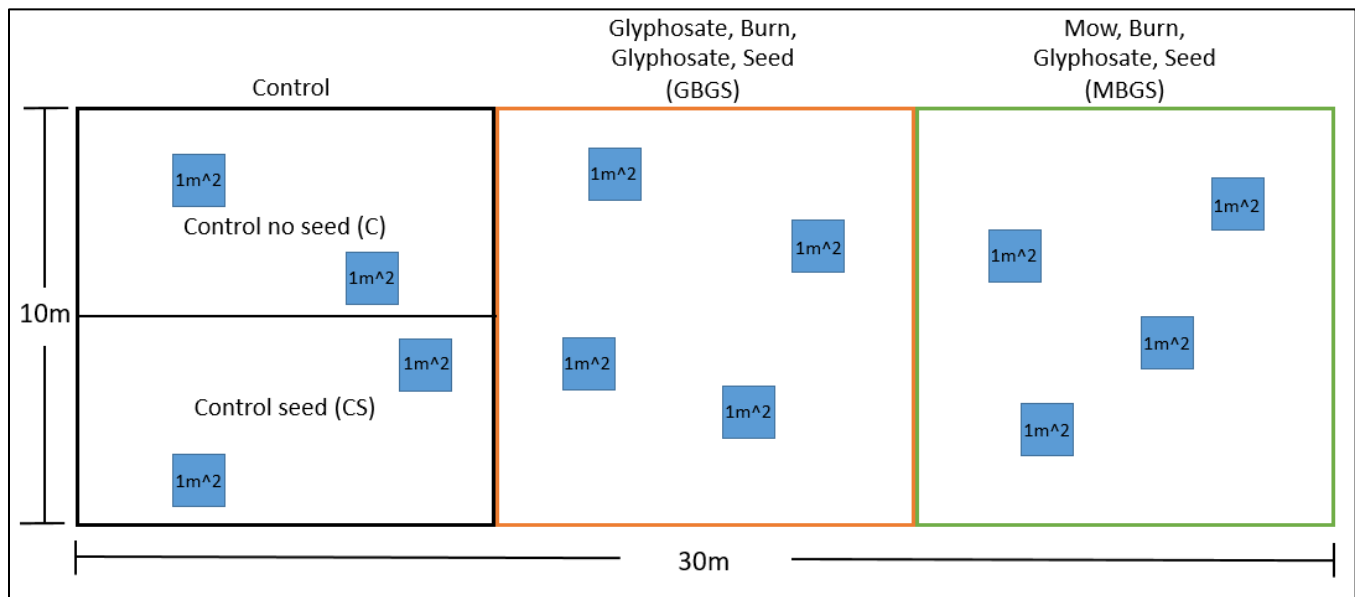


Figure 3. Diagram of oak basin experimental design. One plot is 10m x 30m. Plots are divided into three subplots (10m x 10m). Treatments for each subplot include (1) control, (2) GBGS (glyphosate-flame weed-glyphosate-seed), and (3) MBGS (mow-flame weed-glyphosate-seed). The control is divided further into two subplots: one seeded, one left unseeded. Each subplot was sampled by visually estimating species and ground cover types in four 1 m² quadrats.

Kincaid's lupine

Monitoring of Kincaid's lupine at Oak Basin is meant to be a complete census of the population. In 2006, Meadows A, B, and C were surveyed for the presence of Kincaid's lupine. Plots were then installed around Kincaid's lupine patches. Additional plots have been added as new patches have been located, and all plots are sampled annually. Larger plots are rectangular and marked with fiberglass posts, rebar, or conduit at all four corners. Smaller patches are monitored in either circle or belt transects. Circular plots were marked in the center and all plants were included by setting an appropriate radius. Belt transects were marked on opposite ends, a tape was stretched between the posts, and all of the Kincaid's lupine on either side of the tape was recorded. Each plot origin was tagged with a pre-numbered aluminum tag. Plot notes can be found on the plot maps in Appendix D, Figure 3 and Appendix D, Figure 4. When plants are found outside of existing plots, plot boundaries are either modified or new plots added to accommodate these plants.

Kincaid's lupine is monitored by measuring the area of foliar cover (m²) and counting mature and aborted racemes in each plot. Specifically, Kincaid's lupine foliar cover is measured by taking the approximate length (cm) and width (cm) of area occupied by Kincaid's lupine using standard rulers.

Foliar cover of Kincaid's lupine (as opposed to counting 'individual' plants of this rhizomatous species) is the standard metric for Kincaid's lupine monitoring in the Recovery Plan (USFWS 2010). The percentage of aborted racemes is calculated by dividing the number of aborted racemes by the sum of all mature and aborted racemes and multiplying by 100.

Hitchcock's blue-eyed grass

Two permanent plots were established in 2012 to monitor the small population of Hitchcock's blue-eyed grass in Meadow C at Oak Basin. These same plots were monitored in 2021. The first is a 15m long x 8m wide belt transect with rebar marking both ends. The plot was monitored in 1m sections on the east and west sides of the tape. The origin of the transect is on the south end, tagged with an aluminum tag with #185 stamped on it. The second plot is a 2m radius circular plot with the rebar placed in the center and tagged with #186; plants in this plot are measured in four quadrants. There is a small patch of Kincaid's lupine in this same area, and the circular plot #186 serves as a marker for both the Kincaid's lupine and the Hitchcock's blue-eyed grass. Western blue-eyed grass (*Sisyrinchium bellum*) is also present in the area; for this reason, monitoring occurs at the time of flowering (late June/early July) to ensure proper identification of each species.

Due to the rhizomatous growth of Hitchcock's blue-eyed grass, plants greater than 20cm apart were counted as distinct individuals unless there was clear evidence otherwise (e.g., exposed rhizomes; Groberg et al. 2013). Plants were noted to be either vegetative (V) or reproductive (R). Those that were reproductive were also given a number to represent the number of flowering stems of each plant (e.g., R1 has one flowering stem; R2 has two flowering stems, etc.); individual stems may have more than one flower. In addition, a reproductive plant is likely to have multiple vegetative stems as well.

5. 2021 HABITAT RESTORATION ACTIONS

In 2021, IAE coordinated and implemented a variety of activities to support restoration and conservation efforts in Meadows A, B, C, and D (Table). Restoration actions included mechanical invasive plant treatments, mowing Kincaid's lupine plots, removing conifers between meadows, implementing treatments in experimental plots, collecting seed, and planting plugs (containerized seedlings) in Meadow A. Appendix A includes a summary of completed and proposed restoration activities conducted at Oak Basin from 2012 to 2022.

Table 1. Habitat restoration activities completed at Oak Basin in 2021.

Date	Project task(s)	Personnel
03/18/21	Oak Basin site visit. Met with adjacent landowner to discuss meadow management and opportunities to share resources across ownership.	
04/09/21	Meeting to discuss budgets, workplans, and BLM assistance agreements	
04/19/21	Meeting to discuss 2021 project work	
04/23/21	Pulled Italian thistle plants, flagged experimental plot corners, and took photos	
05/08/21	Took photo points in experimental plots	
06/24/21	Mapped areas for tree removal and corridor creation	
06/28/21	Collected <i>Lupinus oreganus</i> seed	

Date	Project task(s)	Personnel
07/12/21	Met to discuss prescribed burn coordination and site prep	
07/28/21	Cut and removed blackberry and bull thistle in Meadow D	IAE, Looking Glass Youth Crew, Emily Erickson (UWFO BLM)
10/1/21	Spot-sprayed glyphosate in experimental plots to prepare ground for seeding	
10/6/21	Met with BLM to discuss project work	
10/8/21	Mowed 1/4 of <i>Lupinus oreganus</i> population with weed trimmers. Met with adjacent landowner to discuss meadow management and opportunities to share resources across ownership.	
10/21/21	Seeded experimental plots	
10/28/21	Marked trees for removal on both private and public land	IAE, Jim Merzenich, Jessica Celis (UWFO BLM botanist)
11/15/21 and 11/16/21	Cut trees to expand meadow and corridor habitat to increase species connectivity between meadows	Oregon Woods
11/17/21	- Mechanical treatments of blackberry patches on north edge of Meadow B and at the top of corridor between Meadows A and B - Moved logs and created brush piles following tree removal in meadows and corridors	IAE, Lane County Youth Services crew
11/18/21	Planted 495 plugs (containerized seedlings) in Meadow A south of tree island at top of meadow	IAE, Lane County Youth Services crew

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Figure 4. Upper Willamette Field Office upland prairie sites designated as Areas of Critical Environmental Concern.

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Figure 5. Upper Oak Basin 2021 management actions.

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Figure 6. Upper Oak Basin 2021 management actions in Meadow A.

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Figure 7. Upper Oak Basin 2021 management actions in Meadows B, C, and D.

Invasive plant treatments

IAE staff and two youth crews (Looking Glass Youth Crew and the Lane County Youth Services crew) mechanically treated invasive non-native plants at Oak Basin in 2021. Italian plumeless thistle plants were pulled in Meadow B, and Himalayan blackberry and bull thistle plants were cut and pulled in Meadows B and D (Figure 7).

Mowing

On October 8, 2021, seven Kincaid's lupine plots were mowed using a string trimmer to reduce standing thatch and to remove competing non-native perennial grasses (Figure 6, Figure 7, Figure 10). The goal is to mow competing vegetation within approximately 1/4 of the area occupied by Kincaid's lupine in each of the three meadows annually; management of the patches rotates so that each patch is mowed every three years. Appendix B indicates the cover and raceme count of Kincaid's lupine patches and the years in which each patch has been mowed.

Tree removal

In 2021, trees were removed from four acres in the corridors between Meadows A and B and between Meadow A and the Oak Basin Tree Farm meadows (Figure 8, Figure 9). Cut trees were left on the ground in 26 to 30 ft. lengths, and the tops of the trees and branches were removed. In addition, 17 large conifers were limbed to prune branches on tree boles up to 30 feet off the ground. All branches and tree tops were collected into brush piles for burning in the fall of 2022.



Figure 9. Looking NW from Meadow B to Meadow A. Sawyer about 30 ft. up the bole of a large Douglas-fir limbing branches.



Figure 8. Tree limbed and cut. (a) Looking SE from Oak Basin Tree Farm to Meadow A; (b) Looking northwest from Oak Basin Tree Farm to largest meadow on private land.

Experimental treatment plots

In spring 2021, photo points of all 10 experiment plots were taken (Appendix B). In addition, the last two treatments (glyphosate application and seeding) were applied to each of the experimental plots. As described above, each of the 10 experimental plots is divided into three subplots: (1) control; (2) GBGS (glyphosate-flame weed-glyphosate-seed); and (3) MBGS (mow-flame weed-glyphosate-seed). The control is divided further into two subplots: one seeded and one left unseeded. On October 1, we applied a broadcast treatment of glyphosate to the GBGS and MBGS subplots in each experimental plot. We then returned on October 21 to seed the plots (Table 2). In addition to sowing $\frac{1}{2}$ of the control plot and the GBGS and MBGS subplots, we alternated sowing Oregon sunshine (*Eriophyllum lanatum*) from different seed sources (Figure 6, Figure 7, Figure 10). Every other experimental plot received Oregon sunshine seed sourced from the Willamette Valley. The other five experimental plots received Oregon sunshine seed sourced from a mid-elevation upland prairie site like Oak Basin.

To achieve our long-term objectives at the site to (1) maintain and improve quality prairie habitat by removing non-native invasive plants and (2) increase the diversity and areal extent of the native plant community, we are studying the most effective combination of restoration methods to establish native prairie habitat on a large scale. One of the most important components of any successful restoration approach is adequate quantities of native plant materials to use at the site following restoration treatments. Seed for prairie habitat sourced from the Willamette Valley is relatively easy to obtain compared to prairie seed sourced from mid-elevation sites. To restore large areas at Oak Basin, a large amount of seed is required. Weighing the need for large quantities of seed with the need to retain the genetic integrity of upland prairie species was a primary consideration. And because Oak Basin supports the Fender's blue butterfly, another consideration is to ensure that the flowering time of a Fender's blue butterfly nectar species and the flight season of the butterfly coincide. Common woolly sunflower is a nectar source for the Fender's blue butterfly. Sowing seed sourced from lower on the valley floor may result in a later bloom time when sowed at a higher elevation. To determine if there is a biological reason to restrict seed sources to mid-elevation sites, we chose to compare two seed sources of common woolly sunflower. Over the next two years, we will track the growth and phenology of both seed sources to observe whether the plants respond differently to the climate and elevation of the site.

Table 1. Native forb and grass species seeded in experimental plots at Oak Basin fall 2021.

Species	Common Name	Growth Form	Seed Source*	Quantity (lbs.)
<i>Achillea millefolium</i>	common yarrow	forb	ME	0.12
<i>Clarkia amoena</i> ssp. <i>lindleyi</i>	farewell to spring	forb	ME	0.51
<i>Danthonia californica</i>	California oatgrass	grass	ME	2.49
<i>Elymus glaucus</i>	blue wildrye	grass	ME	2.03
<i>Eriophyllum lanatum</i>	common woolly sunflower	forb	ME	0.22
<i>Eriophyllum lanatum</i>	common woolly sunflower	forb	WV	0.22
<i>Festuca roemerii</i>	Roemer's fescue	grass	ME	0.70
<i>Gilia capitata</i>	bluehead gilia	forb	ME	0.17

Species	Common Name	Growth Form	Seed Source*	Quantity (lbs.)
<i>Koeleria macrantha</i>	prairie junegrass	grass	ME	0.15
<i>Plectritis congesta</i>	shortspur seablush	forb	ME	0.40
<i>Prunella vulgaris</i> var. <i>lanceolata</i>	lance selfheal	forb	ME	0.44
<i>Wyethia angustifolia</i>	California compassplant	forb	ME	3.15

*WV = Willamette Valley; ME = mid-elevation



Figure 10.

(a) Mowing Kincaid's lupine plot in Meadow C;
 (b) Recently sprayed experimental plot A2 in Meadow A;
 (c) Seeding experimental plot A1 in Meadow A.



Seed collection

Kincaid's lupine seed was collected in the wild at Oak Basin (on both BLM-administered land and adjacent private land) in late July and from Eagle's Rest in early August. The total amount of wild seed collected from Oak Basin and Eagle's Rest was 61.7g from each site. The seed will be used for growing plugs (containerized seedlings) that will be planted in an established Eugene East seed-increase bed at the IAE farm in spring of 2021.

Planting

On November 18, we planted 495 plugs at the top of Meadow A, just below the largest tree island (Figure 6, Figure 11; Table 2).

Table 2. Native forb species planted as plugs at Oak Basin, Meadow A, in fall 2021.

Species	Common Name	Growth Form	Quantity
<i>Eriophyllum lanatum</i>	common woolly sunflower	forb	118
<i>Geranium oregonum</i>	Oregon geranium	forb	54
<i>Iris tenax</i>	toughleaf iris	forb	93
<i>Sidalcea malviflora</i> ssp. <i>virgata</i>	dwarf checkerbloom	forb	103
<i>Wyethia angustifolia</i>	California compassplant	forb	127



Figure 11. (a) Planting plugs with the Lane County Youth Services crew at the top of Meadow A; (b) California compassplant north of Meadow A at the Oak Basin Tree Farm.

6. RESULTS

Habitat quality

In each meadow, a 25 m² relevé plot was permanently installed in 2020 and surveyed for species richness. Observations are summarized in Table 3. A full list of observed species is provided in Appendix I. Plots are scheduled to be monitored every other year to assess changes in plant community. In 2020 a total of 15 native species were observed and 23 non-native species.

Table 3. Number of species observed within a 5 x 5 m plot in each meadow in 2020, summarized by plant management group and nativity. Plots are scheduled to be monitored on a biennial basis.

Meadow	Number of species observed							
	Forbs		Graminoids		Tree/Shrubs		Total	
	Native	Non-native	Native	Non-native	Native	Non-native	Native	Non-native
A (plot #696)	9	13	6	8	0	0	15	21
B (plot #691)	8	14	4	9	2	0	14	23
C (plot #690)	10	14	6	9	0	0	16	23
Average	9	14	6	9	1	0	15	23

Experimental treatment plots

In 2020, 10 experimental plots were installed for a restoration research project. Treatments for each subplot include (1) control, (2) glyphosate-flame weed-glyphosate-seed (GBGS), and (3) mow-flame weed-glyphosate-seed (MBGS). The control is divided further into two subplots: one seeded, one left unseeded. When plots were established, cover of each plant management group was similar (Table 4, Figure 13). In the first year post-treatment, bare ground was greater in the GBGS plots than in either the control or mowed plots. Cover of introduced graminoids was also lower in the flame-weeded plots compared to MBGS plots (Table 4, Figure 13). Cover of introduced forbs also increased in the GBGS plots over other treatments.

Table 4. Mean plant management group cover (%) by treatment in 2020 (pre-treatment) and 2021. Each experimental plot contains twelve 1x1m subplots in which percent cover was visually estimated for all species.

	2020 – Pre-treatment			2021- First year post-treatment		
	Control	GBGS	MBGS	Control	GBGS	MBGS
Native Forbs	15.4(3.3)	16.2(5.2)	13.7(4.6)	8.7(2.8)	10.5(6)	13.4(5.4)
Native Graminoids	1.5(0.5)	1.6(0.5)	3.2(1.6)	1.8(0.7)	0.9(0.4)	4.6(2.9)
Introduced Forbs	18.8(4.2)	17.4(4.7)	12.4(3.9)	6.7(2.2)	14.4(4.7)	3.1(1.1)
Introduced Graminoids	42.5(7.4)	49.2(8.3)	52.5(6.9)	44.4(7)	10.9(3.5)	34.2(6.9)
Bare Ground	1.4(0.6)	0.6(0.4)	0.5(0.3)	1.2(0.9)	10.4(3.9)	5.4(3.5)
Litter	62.1(3)	56.2(6.1)	65.2(2.9)	66(4)	58.1(7.7)	55.5(7.1)
Moss	1.4(0.7)	10.1(7.4)	1.5(0.6)	1.5(1.6)	6.3(5.5)	1.5(2)
Rock	0.1(0.1)	0.1(0.2)	0.5(0.3)	0.3(0.3)	2.7(3.7)	0.8(0.4)
Basal Vegetation	30.8(2.9)	25(3.5)	36.7(3)	30.8(3.6)	25(4.5)	36.7(6.3)

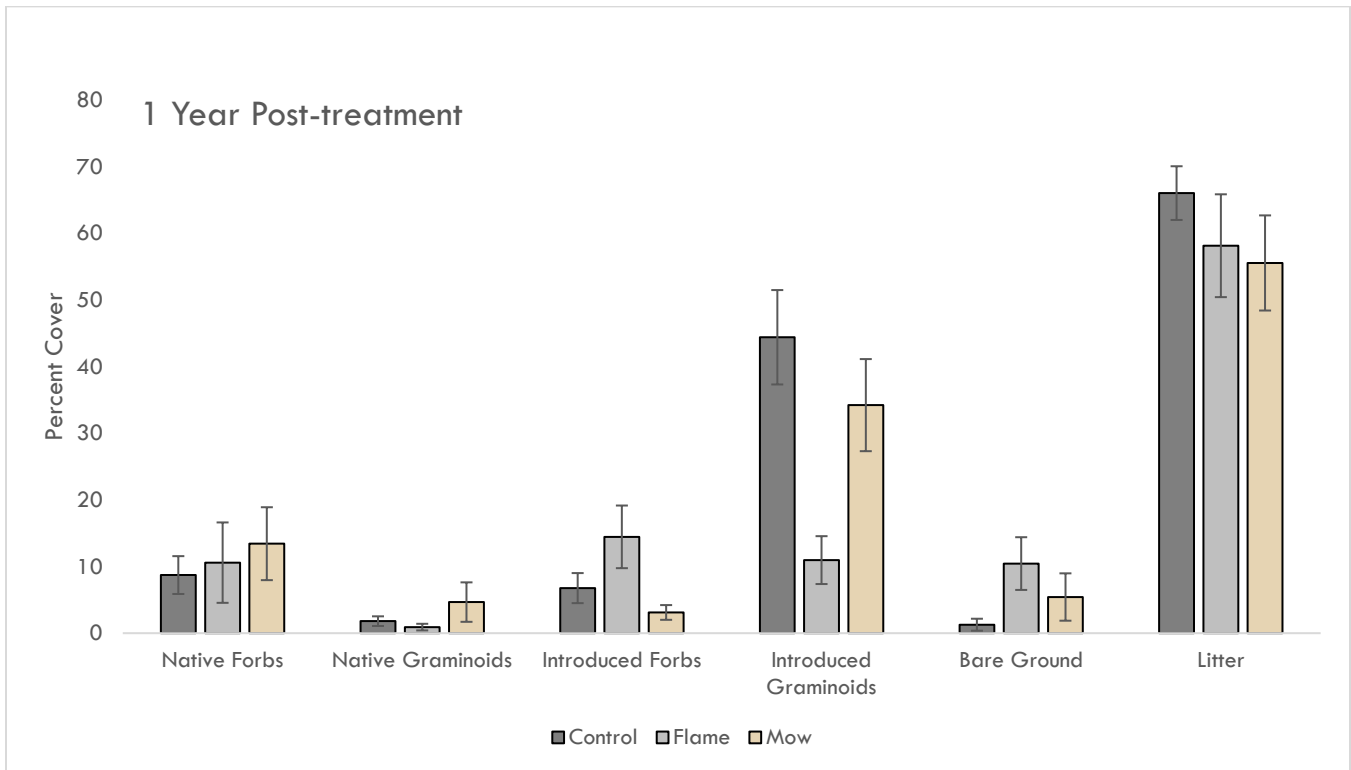


Figure 12. Percent cover by functional group one year post-treatment (2021). Treatments include control, flame weeding (GBGS), and mowing (MBGS). Error bars represent 95% confidence intervals.

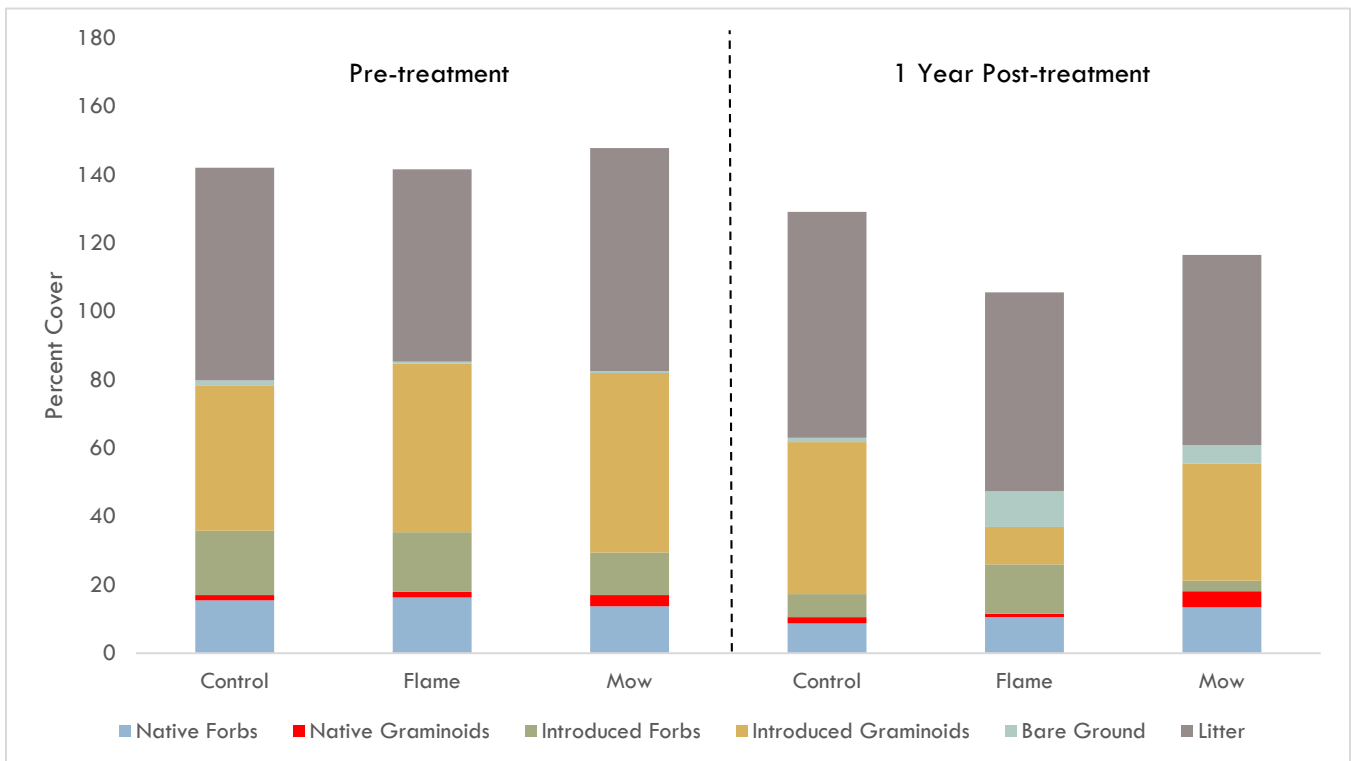


Figure 13. Percent cover of species by Treatment, colored by functional group; pre-treatment (left) and one year post-treatment (right): control, flame weeding (GBGS), and mowing (MBGS).

Kincaid's lupine

In 2021, total Kincaid's lupine foliar cover was 164.9m² across all meadows (Figure 14, Appendix G, Table 5). In 2021, there were 2,472 mature racemes and 342 aborted racemes (13.2%) (Figure 15, Appendix G, Table 4). In 2020, the area of foliar cover was the highest recorded since we started monitoring in 2006, and the mature raceme count was on par with 2019, which was the highest year on record (4,563 racemes). Kincaid's lupine cover increased in Meadows A and B and decreased slightly in Meadow C. Mature raceme count increased in Meadow C to the highest number observed (1,413 mature racemes in 2020). In 2013, a low of 44 reproductive racemes was observed.

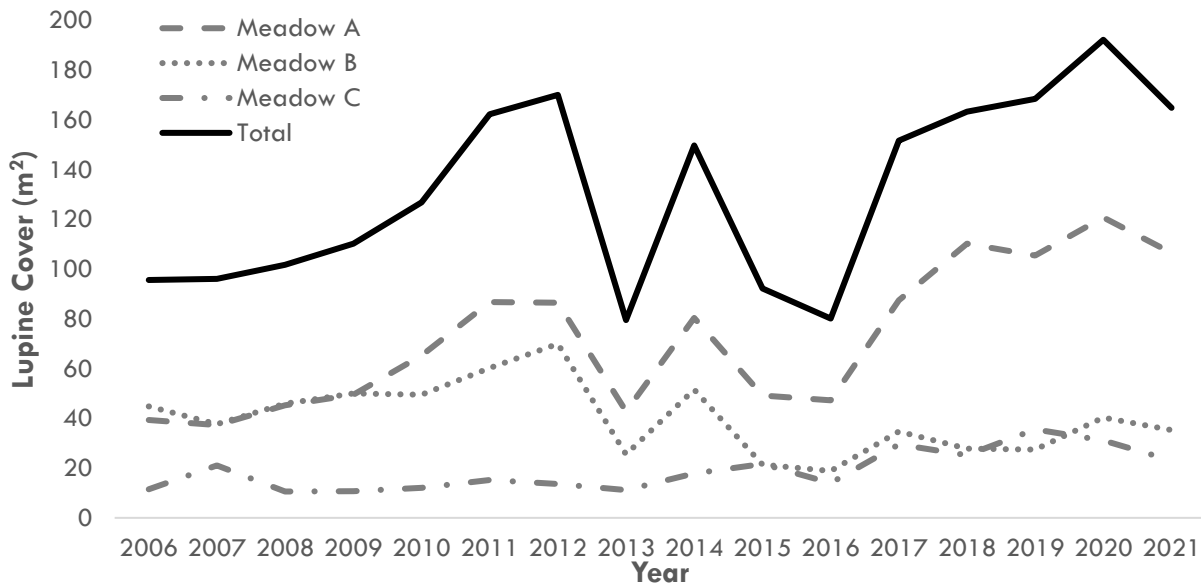


Figure 14. Kincaid's lupine (*Lupinus oreganus*) foliar cover (m²) in each meadow and total cover for all meadows at Oak Basin from 2006 to 2021.

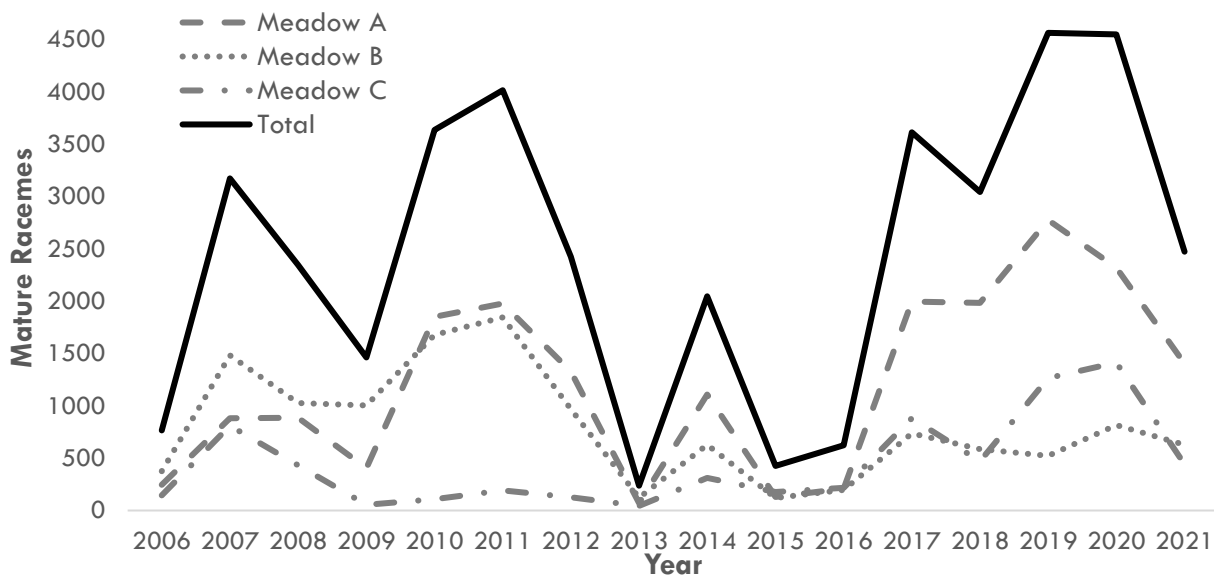


Figure 15. Total mature Kincaid's lupine (*Lupinus oreganus*) racemes counted in each meadow at Oak Basin from 2006 to 2021.

Hitchcock's blue-eyed grass

In 2021, a total of 47 Hitchcock's blue-eyed grass plants were observed, with a total of 21 reproductive stems (Figure 16). This count was the second lowest since monitoring of this species began in 2012. As in previous years, most plants observed in the 4-meter-wide belt transect were found within two meters of the transect tape.

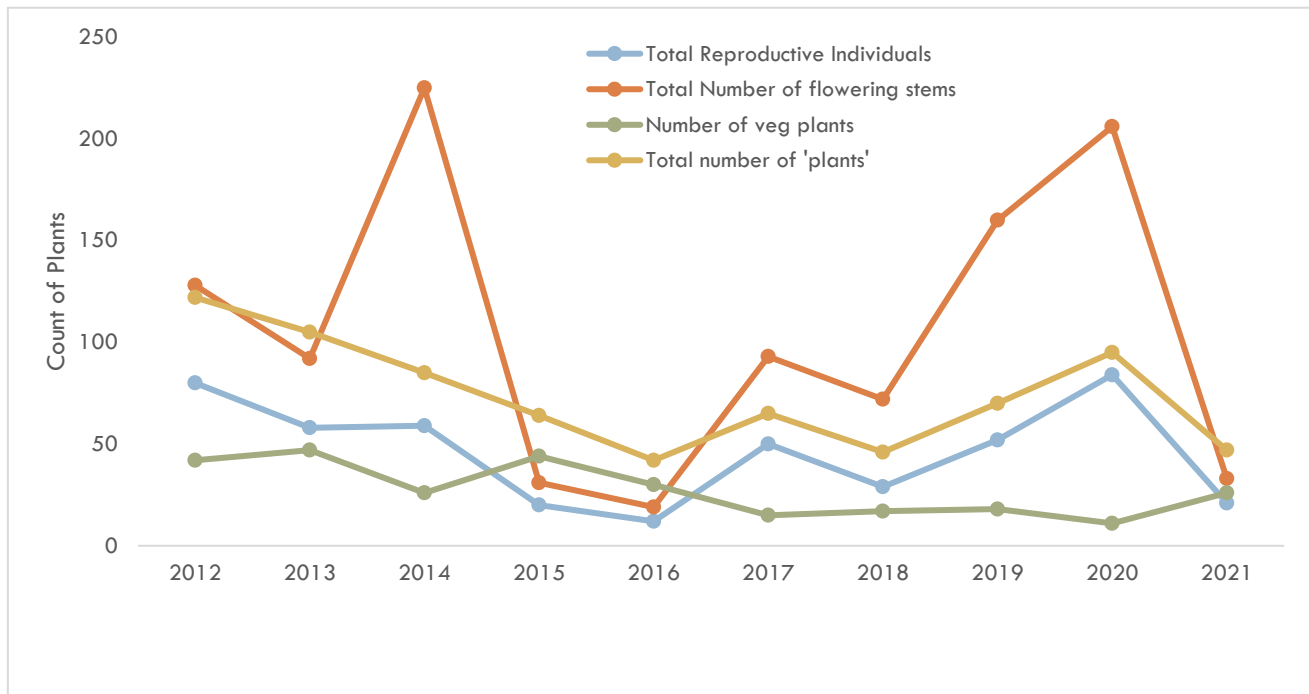


Figure 16. Population trends for Hitchcock's blue-eyed grass (*Sisyrinchium hitchcockii*) in Meadow C at Oak Basin from 2012 to 2021.

7. DISCUSSION

Monitoring Trends

Kincaid's lupine

Over the course of this project there have been periodic fluctuations in Kincaid's lupine foliar cover and raceme counts (cover ranging from 79.6m² to 192.3 m²; raceme count ranging from 237 to 4,563) (Appendix G, Table 3; Appendix G, Table 4). Some of these fluctuations could be linked to climatic stresses; for example, 2015 and 2016 had high temperatures and drought conditions and we observed low cover and raceme counts in those years. Similarly dry conditions in the spring of 2021 likely contributed to decreases in raceme and cover count that was observed across many lupine sites in the Willamette Valley. However, a number of other factors, including habitat management (removal of introduced grasses and limbing of trees adjacent to existing patches of lupine), pollinator access, and others not currently measured or identified also contribute to fluctuations observed in lupine cover and reproduction. The overall decrease in foliar cover from 2012 to 2016 led to a re-evaluation of management actions and more management actions. Lupine cover has generally increased from 2016 to the present concomitant with increased management activities at the site.

The total number of racemes has followed a similar pattern to lupine foliar cover at Oak Basin (Figure 14, Figure 15). As with foliar cover, climate differences, competition from non-native plants, and other factors related to habitat degradation may contribute to observed fluctuations in raceme count and flowering success.

Direct competition from introduced grasses, which have steadily increased in cover in recent years, may be a key driver of reduced lupine foliar cover over the long term. Additionally, the tall stature of these perennial grass species could potentially reduce reproductive success by limiting pollinator access (Sletvold et al. 2013). Furthermore, lupine plants growing in competition with introduced perennial grasses often have fewer leaves and larger gaps between leaves (Giles, personal observation); leaves are the crucial egg-laying zones for the Fender's blue butterfly. Nectar surveys in 2011 indicated that, while nectar species were present at the site, there may not have been enough available (both the number of species and number of flowers) through the duration of the butterfly's flight period for Fender's blue butterflies to thrive (Giles-Johnson et al. 2011), a condition that may also be true for other pollinators.

Hitchcock's blue-eyed grass

Over the past nine years of monitoring, our data show a general downward trend in the Hitchcock's blue-eyed grass population at Oak Basin, despite some expected annual fluctuation. As a caveat, it is acknowledged by Groberg et. al. (2013) that the methodology we currently use may under-represent the true number of individuals present. Hitchcock's blue-eyed grass individuals may spread through rhizomatous growth into neighboring plants, potentially resulting in the grouping of separate individuals that are then counted as one during monitoring. Despite the potential limitations of the sampling method with regard to the total number of individuals, this does not affect the total count of reproductive stems of the population, which is an important indicator of population health. The total number of vegetative plants has decreased over the course of the study, but reproductive stems have fluctuated more widely, decreasing in 2021 to the second lowest recorded count (Figure 16; Appendix H, Table 6). These fluctuations in reproductive stem counts may be influenced by environmental factors, and booms in reproductive effort may not always correspond to overall population success.

Monitoring of the Hitchcock's blue-eyed grass remains vital to ensure its continued viability and to illustrate the need for active management of the population. The general downward trend and the extremely small size of the population merits continued monitoring efforts and habitat management to improve habitat quality in order to ensure the longevity of this small population, which occupies less than 50m² in Meadow C (Figure 16).

Experimental treatment plots

In the first year post-treatment, the glyphosate-flame weeding-glyphosate-seed (GBGS) resulted in increased bare ground and lower cover of introduced graminoids. GBGS also resulted in higher cover of introduced forb species; however, seeding efforts in 2021 and 2022, should contribute to increased cover of native species in the future. The mowing-flame weeding-glyphosate-seed treatment did not result in significant changes to the cover of introduced species or to ground-cover classes.

Synthesis

In order to reach recovery goals for Kincaid's lupine, continued monitoring of both this species and its associated plant community will be vital. Annual fluctuations in raceme count and foliar cover of lupine highlight the need for ongoing monitoring of extant populations in order to assess the status and overall trend of these populations in order to meet recovery goals (USFWS 2010). The prevalence of introduced grasses in the plant community continues to pose a challenge for the restoration of both Kincaid's lupine and Hitchcock's blue-eyed grass at Oak Basin. To assess the progress that has been made towards the Kincaid's lupine recovery goals, we have summarized data for 202 to compare current conditions to the habitat-quality targets listed in the Recovery Plan (Table 5; USFWS 2010).

Table 5. Summary of current Oak Basin prairie habitat quality compared to recovery goals. Trends summarize 14 years (2006-2021) of population and community monitoring data.

Prairie Quality and Diversity Summary*			
Criteria	Data	Recovery Plan threshold*	Meets Recovery Plan objectives?
Fender's blue butterfly population size**	BLM-administered land: 36; private land: 2	Minimum population size of 200 individuals over 10 years	No
Trend of Kincaid's lupine population size (foliar cover, m ²)	Increased on average 3.6 m ² /year	Increasing (+ slope) or stable (0 slope) over 15 years	Yes***
Target foliar cover for Kincaid's lupine downlisting	Total: 192.3 m ² Meadow A: 120.8 m ² Meadow B: 40.3 m ² Meadow C: 31.1 m ²	5,000 m ² in Eugene East Recovery Zone; minimum of 100m ² in each meadow to count towards recovery	Mixed
Evidence of lupine reproduction	7.18 g seed collected on BLM-administered land only	Seedset or presence of seedlings	Mixed – no seedset in some meadows
Native herbaceous species relative cover	15%	50% min	No
Woody species cover	8%	15% max	Yes
Do any woody species of management concern exceed 5% cover?	No	5% max	Yes
Prairie diversity: Native forb richness	9	7	Yes
Prairie diversity: Native bunchgrass richness	1	1	Yes
Prairie diversity: Total native herbaceous species richness	15	>10	Yes
Sufficient abundance of nectar species	2 Native, 5 Non-native	5 native species	No

*From the *Recovery Plan for the Prairie Species of Western Oregon and Southwestern Washington* (USFWS 2010).

** Data from Diaz 2020

*** While still a positive trend, note that every site decreased from 2020 to 2021.

8. CONCLUSIONS AND MANAGEMENT RECOMMENDATIONS

Annual monitoring data show that recent restoration efforts at Oak Basin have put the site on the right trajectory with regard to increased Kincaid's lupine foliar cover and evidence of reproduction. However, Oak Basin is still falling short of meeting several aspects of the criteria outlined in the Recovery Plan, including the overall population size of Fender's blue butterfly, Kincaid's lupine foliar cover, and several measures of habitat quality. These data highlight where to focus future restoration efforts at Oak Basin and also guide future monitoring methods.

Continued restoration needs to be a priority, with the goals of increasing the population size of Kincaid's lupine at Oak Basin and improving habitat quality. To accomplish these goals, larger areas of meadow need to be treated using fire and herbicides. As an example, although we have consistently mowed Kincaid's lupine patches as a means of controlling tall fescue, it is not recommended as a long-term solution for control of introduced perennial grasses, as many have been selected for traits that allow recovery following defoliation. Tall fescue must be treated using herbicides or through tillage (Indiana Division of Fish and Wildlife 2006), which would negatively impact the native plant community. Alternatively, prescribed fire followed by spot herbicide application could provide more targeted control of tall fescue and other non-native plants. These treated areas would need to be subsequently seeded and planted with native graminoids and forbs, including Kincaid's lupine and others that serve as nectar species for the Fender's blue butterfly. It will still be important to use an integrated management approach at the site and to continue to hand-pull small isolated populations of non-native invasive plants such as Scotch broom, Himalayan blackberry, and Italian plumeless thistle. Additionally, conifer recruitment should be addressed by cutting saplings rather than allowing trees to grow larger. To address the problem of low Fender's blue butterfly counts at the site, a large number of trees have been removed, girdled, or limbed since 2015. Just in 2021 alone, 4 acres of meadow corridors were treated to increase connectivity between BLM-managed meadows and those located on Oak Basin Tree Farm. Once corridors are opened up, follow-up treatments are necessary to prevent non-native shrubs from colonizing the site.

The following habitat management, monitoring activities, and recovery actions are recommended at Oak Basin in 2022 and beyond:

- Monitor outplantings of Kincaid's lupine at Oak Basin Tree Farm.
- Monitor Fender's blue butterfly nectar availability at least once every three years.
- Initiate active restoration of Hitchcock's blue-eyed grass habitat and augment population in Meadow C by putting this species into production (collecting seed in the wild and growing plugs and/or increasing seed).
- Continue to monitor and assess efficacy of management treatments to reduce abundance of non-native plants through appropriate weed-control measures.
- Continue to treat non-native plants using all available methods, including spot-spraying non-native perennial species with herbicide.
 - Continue non-native species treatment between meadows, in particular between Meadows A and B.
 - Hand-pull all populations of Italian thistle annually.
 - Spot-spray Himalayan blackberry in all meadows.
- Pending authorization of the use of prescribed fire, initiate fire treatments in 2023-2024 in Meadow A.

- Continue to increase nectar availability for Fender's blue butterfly and native species cover and diversity by augmenting native forb resource plants through seeding and/or outplanting of plugs.
 - Seed/plant nectar and host plant species in experimental plots depending on the abundance of non-native species after two seasons of treatment.
 - Maintain Eugene East Recovery Zone seed-production beds for Kincaid's lupine.
 - Collect wild native seed from Oak Basin and other mid-elevation sites for starting seed-increase beds, growing plugs for introduction, and/or direct sowing in disturbed areas.
 - Maintain mid-elevation seed-production beds (funded through a separate agreement).
 - Augment Kincaid's lupine population with transplants or seeds from appropriate seed sources.

Continued population monitoring will be essential to document population trends for both species, especially in response to restoration activities occurring at the site, and to track whether the Kincaid's lupine population is meeting recovery goals. Targeted community monitoring of areas pre- and post-treatment will be used to further guide management and restoration treatments. In 2020, relevé plots were established to monitor species richness in the target reference 25 m² area (as recommended in the Recovery Plan) and plots for a multi-year treatment experiment were installed. Relevé plots will be monitored on a biennial basis to assess changes in the plant community. Monitoring of the treatment plots is recommended to continue in 2022 and again in 2024.

The Institute for Applied Ecology is working in partnership with the BLM and Oak Basin Tree Farm to coordinate restoration efforts in the area. Ongoing plant community, Kincaid's lupine, and Hitchcock's blue-eyed grass monitoring will enable us to assess effects and to continue to make progress in habitat restoration at the site.

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APPENDIX A. SUMMARY OF COMPLETED AND PROPOSED MANAGEMENT ACTIONS AT OAK BASIN (2012-2022)

2012 Management Actions

- Site inspection and partner coordination

2013 Management Actions

- Site inspection and partner coordination
- Mapped *Taeniatherum caput-medusae* (medusahead) locations
- Mowed around perimeter of all lupine patches and inside 1/3 of all lupine patches
- Mowed all major *R. armeniacus* patches
- Grubbed several *R. armeniacus* patches
- Flame-weeded patches for *T. caput-medusae* control and site preparation for planting/seeding

2014 Management Actions

- Site inspection and partner coordination
- Flame-weeded patches for medusahead control and site preparation for planting/seeding
- Planted 882 bulbs plus 2 15"x15" trays of *Allium amplexans*, 784 rhizomes of *Iris tenax*, 670 plugs of *Eriophyllum lanatum*, and 8 *Balsamorhiza deltoidea* plants
- Seeded 7.14 lbs. *Bromus carinatus*, 4.83 lbs. *Elymus glaucus*, 1.27 lbs. *Elymus trachycaulis*, 0.50 lbs. *Eriophyllum lanatum*, 1.50 lbs. *Festuca roemerii*, 0.70 lbs. *Plectritis congesta*, 1.14 lbs. *Prunella vulgaris* var. *lanceolata*, and 1.71 lbs. *Sidalcea malviflora* ssp. *virgata*
- Nectar plant availability assessment
- Hand-weeded *Cirsium vulgare* and *Cytisus scoparius*
- Mowed 1/3 of all lupine patches and some *R. armeniacus* patches
- Grubbed *R. armeniacus*

2015 Management Actions

- Site inspection and partner coordination
- Grubbed *R. armeniacus*
- Removed small-diameter conifers around perimeter of meadows
- Removed, limbed, or girdled trees around edges of meadows and in corridors between meadows. Similar work also done on adjacent Merzenich property.
- Flame-weeded patches for medusahead control and site preparation for planting/seeding
- Planted native plugs: 280 *Danthonia californica*, 100 *Elymus trachycaulis*, 150 *Festuca californica*, 200 *Festuca roemerii*, 1200 *Geranium oreganum*, 2000 *Iris tenax*, 120 *Lomatium dissectum*, and 5600 *Sidalcea malviflora* ssp. *virgata*
- Seeded 3.15 lbs *Danthonia californica*, 1.5 lbs. *Eriophyllum lanatum*, 9.40 lbs. *Festuca californica*, 6.0 *Festuca roemerii*, 3.0 lbs. *Prunella vulgaris* var. *lanceolata*, and 3.0 lbs. *Sidalcea malviflora* ssp. *virgata*
- Mowed 1/3 of all lupine patches

2016 Management Actions

- Site inspection and partner coordination
- Flame-weeded medusahead control and site preparation for planting/seeding
- Grubbed *R. armeniacus*
- Removed small-diameter conifers around perimeter of meadows
- Hand-weeded *Cytisus scoparius*
- Mowed 1/3 of all lupine patches
- Planted plugs: 40 *Danthonia californica*, 50 *Iris tenax*, and 400 *Sidalcea malviflora* ssp. *virgata*

2017 Management Actions

- Site inspection and partner coordination
- Outplanted 68 plugs of *Lupinus oreganus* on neighboring private land (Oak Basin Tree Farm)
- Flame-weeded patches for medusahead control and site preparation for seeding
- Grubbed *R. armeniacus*
- Seeded *Danthonia californica* 2.37 lbs, *Elymus trachycaulis* 2.0 lbs, *Eriophyllum lanatum* 1.28 lbs, *Festuca roemerii* 3.41 lbs, *Plectritis congesta* 1.18 lbs, *Prunella vulgaris* var. *lanceolata* 0.75 lbs, and *Sidalcea malviflora* spp. *virgata* 1.0 lbs
- Mowed approximately one-third of lupine patches after senescence of *L. oreganus*
- Hand-mowed flame-weeded plots A3, A4, B3, and B4 in Meadows A and B

2018 Management Actions

- Site inspection and partner coordination.
- Monitored 38 outplanted plugs of *Lupinus oreganus* on neighboring private land (Oak Basin Tree Farm); 18 survived
- Flame-weeded patches for medusahead control and site preparation for seeding in Meadows A and B
- Grubbed *R. armeniacus*
- Pulled Scotch broom, Italian thistle, and shining geranium (geranium pulled near lupine patch 460 in Meadow A only)
- Cut seedlings and saplings from edges of all meadows. They were particularly concentrated in Meadow C.
- Mowed approximately one-third of lupine patches after senescence of *L. oreganus*
- Seeded flame-weeded areas (~0.67 acres) with a native forb and grass mix: *Danthonia californica* (1.87 lbs.), *Elymus glaucus* (1.45 lbs.), *Eriophyllum lanatum* (0.28 lbs.), *Koeleria micrantha* (0.09 lbs.), *Plectritis congesta* (0.46 lbs.), *Prunella vulgaris* (0.38 lbs.), and *Wyethia angustifolium* (3.27 lbs.)

2019 Management Actions

- Site inspection and partner coordination
- Monitored 50 outplanted plugs of *Lupinus oreganus* on neighboring private land (Oak Basin Tree Farm); 18 survived
- Cut seedlings and saplings from edges of Meadow A and between Meadows A and B

- Grubbed *R. armeniacus* in Meadows B and C
- Pulled Scotch broom and Italian thistle in Meadows A and B
- Flame-weeded patches for non-native annual and perennial graminoid control in all meadows, including three new flame-weeded patches and the *Sisyrinchium hitchcockii* population
- Subcontracted the cutting of 60 trees between and along the edges of Meadows A and B ranging in size from 10 to 20 inches in diameter
- Led an AmeriCorps Blue 5 Team in the piling and moving of downed trees from the meadows and meadow corridor
- Seeded areas disturbed by tree removal with a native forb and grass mix: *Danthonia californica* (0.87 lbs.), *Elymus glaucus* (1.10 lbs.), *Festuca roemerii* (0.34 lbs.), and *Wyethia angustifolium* (2.20 lbs.)

2020 Management Actions

- Site inspection and partner coordination
- Tree removal between Meadows B and C
- Hand-pulled Italian plumeless thistle from Meadow B, Scotch broom from Meadow A, and grubbed Himalayan blackberry from Meadow C
- Installed restoration experimental plots
- Collected Kincaid's lupine seed
- Mowed Kincaid's lupine plots in Meadows A, B, and C, the furthest east subplot of all 10 experimental plots and a six-foot-wide path between Meadows A and B using a weed trimmer
- Spot-sprayed non-native species in all experimental plots with Glyphosate
- Removed a large tree in corridor between Meadows A and B
- Flame-weeded two patches of annual grasses (A5 and A6) and all experimental plots in Meadow A. Activity approved by BLM fire duty officer Sean Sheldon.
- Took photo points
- Broadcast a seed mix in flame-weeded patches A5 and A6
- Cut down approximately 35 conifers along the forest/meadow edge in Meadow C
- Established Eugene East Recovery Zone seed-production beds for Kincaid's lupine
- Monitored Kincaid's lupine and Hitchcock's blue-eyed grass

2021 Management Actions

- Site inspection and partner coordination
- Tree removal over four acres of meadow between Meadows A and B and between Meadow A and the Oak Basin Tree Farm
- Limbed 18 large conifers
- Piled limbs into brush piles for burning
- Hand-pulled Italian plumeless thistle and bull thistle from Meadows B and C; cut Himalayan blackberry from Meadows B and D
- Collected Kincaid's lupine seed
- Mowed Kincaid's lupine plots in Meadows A, B, and C
- Spot-sprayed non-native species in all experimental plots with glyphosate

- Took photo points in experimental plots
- Broadcast seed in experimental plots
- Continued Eugene East Recovery Zone seed-production beds for Kincaid's lupine
- Monitored Kincaid's lupine and Hitchcock's blue-eyed grass
- Planted 495 plugs at the top of Meadow A

2022 Management and Monitoring Actions (proposed)

- Monitor outplanting of Kincaid's lupine plugs at Oak Basin Tree Farm.
- Monitor Fender's blue butterfly nectar availability at least once every three years.
- Initiate active restoration of Hitchcock's blue-eyed grass habitat and augment population in Meadow C by putting this species into production (collecting seed in the wild and growing plugs and/or increasing seed).
- Continue to monitor and assess efficacy of management treatments to reduce abundance of non-native species through appropriate weed-control measures.
- Continue to treat non-native species using all available methods, including spot-spraying non-native perennial species with herbicide.
 - Continue treatment of non-native species between meadows, in particular between Meadows A and B.
 - Hand-pull all populations of Italian thistle annually.
 - Spot-spray Himalayan blackberry in all meadows.
- Pending authorization of the use of prescribed fire, initiate fire treatments in 2023-2024 in Meadow A.
- Continue to increase nectar availability for Fender's blue butterfly and native species cover and diversity by augmenting native forb resource plants through seeding and/or outplanting of plugs.
 - Seed/plant nectar and host plant species in experimental plots depending on the abundance of non-native species after two seasons of treatment.
 - Maintain Eugene East Recovery Zone seed-production beds for Kincaid's lupine.
 - Collect wild native seed from Oak Basin and other mid-elevation sites for starting seed-increase beds, growing plugs for introduction, and/or direct sowing in disturbed areas.
 - Maintain mid-elevation seed-production beds (funded through a separate agreement).
 - Augment Kincaid's lupine population with transplants or seeds from appropriate seed sources.

APPENDIX B. EXPERIMENTAL PLOT PHOTO POINTS (2021)

Photo points were taken standing in the center on the south edge of each subplot.



Experimental plot A1. (left to right) control, GBGS (glyphosate-flame weed-glyphosate-seed), MBGS (mow-flame weed-glyphosate-seed)



Experimental plot A2. (left to right) control, GBGS (glyphosate-flame weed-glyphosate-seed), MBGS (mow-flame weed-glyphosate-seed)



Experimental plot A3. (left to right) control, GBGS (glyphosate-flame weed-glyphosate-seed), MBGS (mow-flame weed-glyphosate-seed)



Experimental plot A4. (left to right) control, GBGS (glyphosate-flame weed-glyphosate-seed), MBGS (mow-flame weed-glyphosate-seed)



Experimental plot B1. (left to right) control, GBGS (glyphosate-flame weed-glyphosate-seed), MBGS (mow-flame weed-glyphosate-seed)

Experimental plot B2. Close up of MBGS
(mow-flame weed-glyphosate-seed)
subplot dominated by toughleaf iris



Experimental plot B2. (left to right) control, GBGS (glyphosate-flame weed-glyphosate-seed), MBGS (mow-flame weed-glyphosate-seed)



Experimental plot B3. (left to right) control, GBGS (glyphosate-flame weed-glyphosate-seed), MBGS (mow-flame weed-glyphosate-seed)



Experimental plot C1. Close up of GBGS
(glyphosate-flame weed-glyphosate-seed)



Experimental plot C1. (left to right) control, GBGS (glyphosate-flame weed-glyphosate-seed), MBGS (mow-flame weed-glyphosate-seed)



Experimental plot C2.
Close up of control subplot



Experimental plot C2. (left to right) control, GBGS (glyphosate-flame weed-glyphosate-seed), MBGS (mow-flame weed-glyphosate-seed)



Experimental plot C3. (left to right) control, GBGS (glyphosate-flame weed-glyphosate-seed), MBGS (mow-flame weed-glyphosate-seed)

APPENDIX C. KINCAID'S LUPINE COVER AND RACEME COUNTS BY PLOT (2013-2021)

Appendix C, Table 1. Kincaid's lupine (*Lupinus oreganus*) raceme counts by plot from 2013 to 2021. Shaded cells indicate which plots were mowed in the preceding fall.

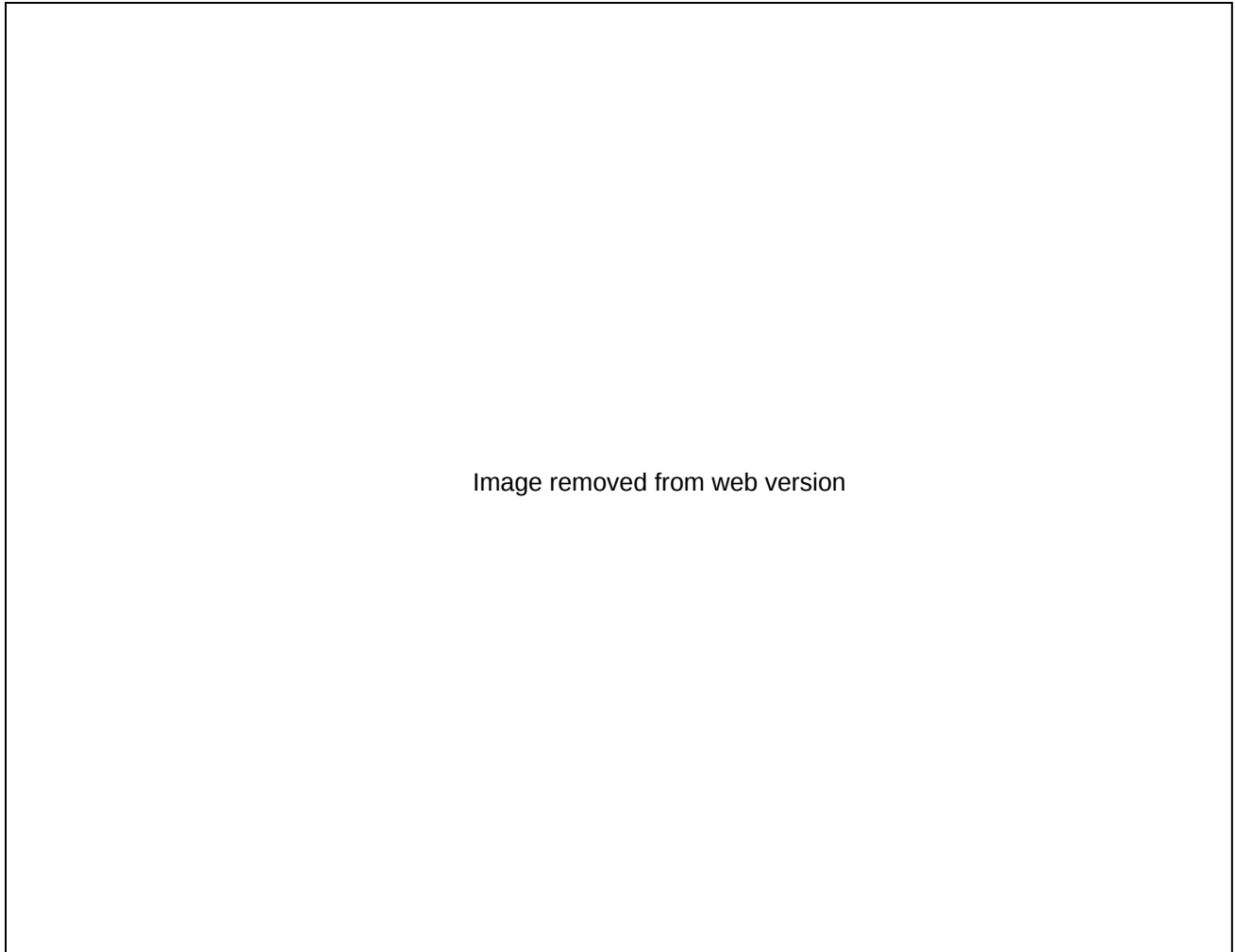
	Plot	2013	2014	2015	2016	2017	2018	2019	2020	2021
Meadow A	7	10	36	10	12	201	62	145	164	7
	8	3	1	-	-	4	6	9	19	-
	9	2	146	24	5	49	30	25	162	14
	10	-	18	3	-	8	3	3	29	4
	369						50	-	8	14
	406	1	-	-	2	1	-	1	12	-
	450	23	30	21	22	29	7	93	251	111
	451	-	4	-	-	16	-	-	-	-
	452	6	93	9	-	129	34	25	116	67
	454	4	10	-	-	36	3	27	42	15
	459	6	361	9	-	1,069	669	1,142	555	517
	460	2	192	12	117	206	785	589	223	365
	464	4	118	2	-	126	23	90	83	12
	509	8	52	30	51	56	239	462	550	176
	510	-	14	4	-	1	8	14	43	15
	511	2	33	5	-	65	65	127	56	86
	653							23	7	-
Meadow A Total		71	1,108	129	209	1,996	1,984	2,775	2,320	1,403
Meadow B	1	20	309	31	43	441	379	198	222	175
	2	1	1	1	-	3	1	-	-	-
	3	5	21	7	13	15	5	16	49	72
	4	2	23	7	-	40	2	6	-	6
	5	2	114	50	25	19	22	67	134	184
	6	51	125	24	21	51	107	36	80	71
	399	41	34		95	167	71	200	330	119
Meadow B Total		122	627	120	197	736	587	523	815	627
Meadow C	184	-	-	-			1	3	7	13
	233			-		2	-	4	2	8
	400	-	1	1	3	-	-	2	7	-
	431	-	20	8	-	62	32	99	162	70
	432	42	173	86	187	408	322	741	1,010	251
	433	2	117	82	14	408	78	372	213	94
	594				13	1	38	44	12	6
Meadow C Total		44	311	177	217	881	471	1,265	1,413	442
Grand Total		237	2,046	426	623	3,613	3,042	4,563	4,548	2,472

Appendix C, Table 2. Kincaid's lupine (*Lupinus oreganus*) cover by plot from 2013 to 2021.
Shaded cells indicate which plots were mowed in the preceding fall.

	Plot	2013	2014	2015	2016	2017	2018	2019	2020	2021
Meadow A	7	1.1	2.9	1.8	1.9	2.8	1.8	2.1	4.1	0.4
	8	0.3	0.2	0.1	0.1	0.3	0.4	0.3	0.5	0.0
	9	4.7	6.4	3.2	2.2	4.7	6.0	4.3	7.4	1.8
	10	0.4	0.8	0.4	0.6	0.5	0.6	0.5	0.8	0.5
	369						10.9	7.8	13.8	14.0
	406	0.7	0.3	0.0	0.1	0.3	0.4	0.5	0.4	0.2
	450	10.8	11.3	7.5	3.9	6.2	7.4	15.0	10.5	13.5
	451	0.7	1.6	0.6	0.9	1.4	1.4	0.5	0.9	0.6
	452	3.4	10.0	8.5	3.8	11.1	10.4	8.0	8.3	12.8
	454	1.8	5.7	2.6	1.3	6.8	6.4	4.7	5.7	6.9
	459	9.7	19.3	11.9	16.8	26.3	39.3	25.1	35.2	29.9
	460	2.4	4.8	3.0	2.5	6.5	6.4	10.1	8.7	9.9
	464	5.3	13.8	6.4	7.9	17.4	12.0	14.9	9.6	7.3
	509	1.0	1.5	1.6	0.7	2.3	5.0	7.1	10.4	5.3
	510	0.3	1.4	1.3	0.0	0.1	0.8	1.6	2.2	1.3
	511	0.4	0.5	0.3	4.5	0.8	1.2	1.2	1.4	1.5
	653							2.1	0.9	0.6
Meadow A Total		42.9	80.4	49.2	47.3	87.5	110.3	105.5	120.8	106.6
Meadow B	1	8.6	31.3	11.8	8.8	23.2	12.1	13.5	16.9	18.9
	2	0.5	0.5	0.1	0.0	0.1	0.0	0.0	0.0	0.1
	3	2.0	3.2	1.6	1.5	1.3	0.5	1.0	3.6	2.6
	4	1.7	2.5	0.7	0.9	1.5	0.4	1.1	0.7	0.9
	5	4.3	6.2	4.3	1.7	1.6	4.5	3.8	5.9	4.8
	6	3.6	4.6	2.9	2.3	2.5	4.3	1.9	3.8	4.2
	399	4.9	3.3	0.0	3.7	4.6	6.1	6.1	9.4	3.9
Meadow B Total		25.5	51.6	21.4	18.9	34.7	27.9	27.4	40.3	35.3
Meadow C	184	0.0	0.0	0.0			0.1	0.2	0.4	0.6
	233			0.0		0.1	0.0	0.1	0.1	0.0
	400	0.1	0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.0
	431	1.8	2.7	3.1	1.6	3.9	2.6	4.4	6.1	4.8
	432	5.1	10.1	9.4	7.4	12.2	12.4	20.4	16.1	8.2
	433	4.2	4.8	9.1	4.3	12.3	8.7	9.1	6.6	7.3
	594				0.7	0.9	1.3	1.5	1.8	2.2
Meadow C Total		11.2	17.8	21.7	14.0	29.5	25.2	35.6	31.1	23.1
Grand Total		79.6	149.8	92.3	80.2	151.7	163.4	168.6	192.3	164.9
*Values with 0.0 do not show due to rounding. Some lupine is present. Blanks indicate that the plot was not monitored or established in that year.										

APPENDIX D. AERIAL OVERVIEWS

Overview of Meadows A, B and C



Appendix D, Figure 1. Aerial overview of the Oak Basin study area, including meadow names. Detailed maps of each meadow and plot numbers from our study are included below.

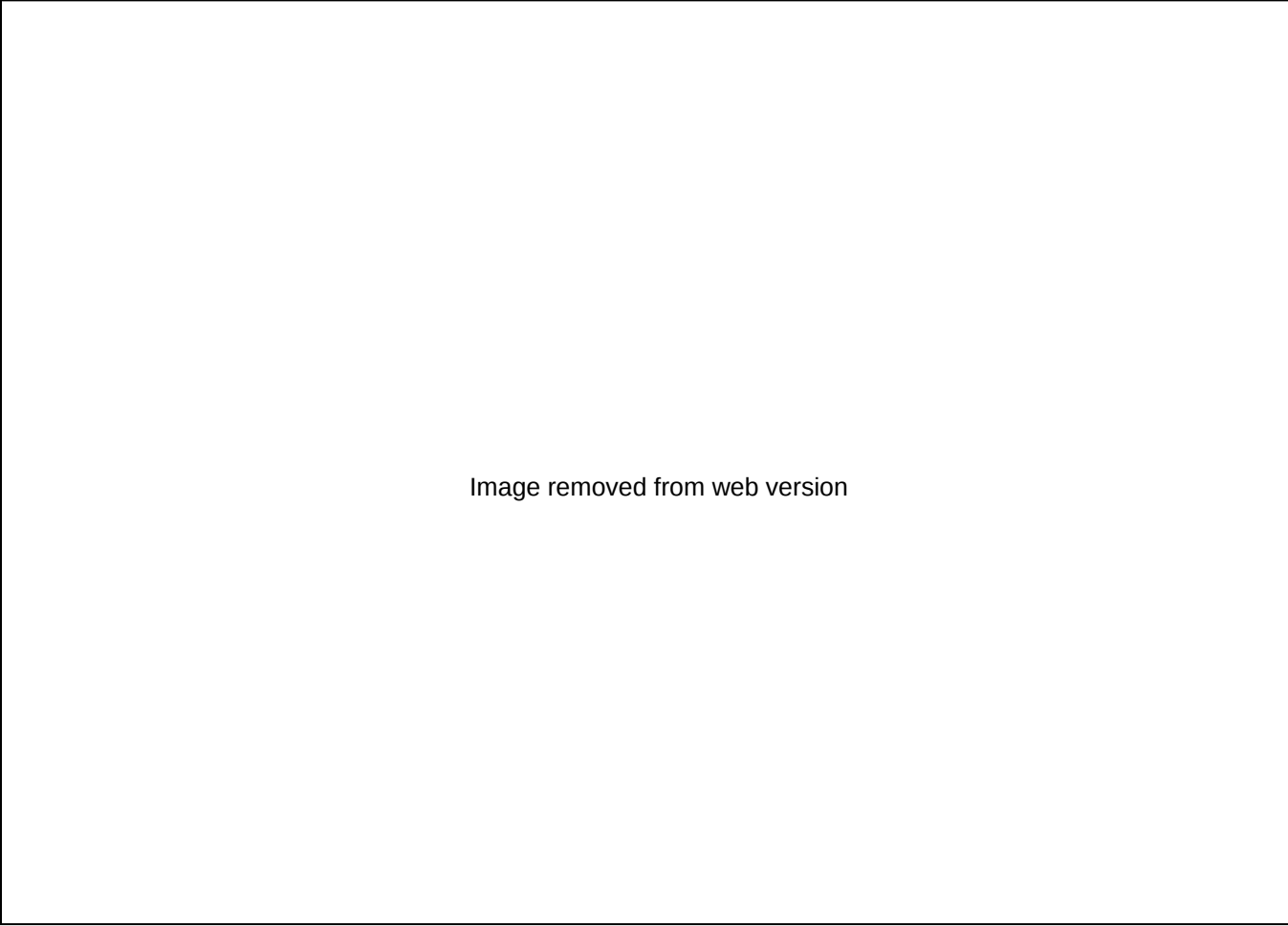


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Appendix D, Figure 2. Aerial photo of the three meadows at Oak Basin that contain patches of Kincaid's lupine (*Lupinus oreganus*). Plot numbers and meadow names are indicated.

Meadow A overview

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Appendix D, Figure 3. Meadow A overview. Plots established in 2011 = 509, 510, 511. The 509 east population is located on the skid road and exists within a 1.5m radius of the rebar. The 510 west population is located on the tree line at 179° from a large Douglas-fir (*Pseudotsuga menziesii*) near the center of the hill and extends in a 8m x 1m strip going north-south. The 511 center population is located in the middle of the hill at 230° from the westernmost Douglas-fir in a Douglas-fir island located on the top of the hill near plot 459; the population consists of 5 plants in a 3m x 0.5m strip going north-south.

Meadows B and C overview

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Appendix D, Figure 4. Meadows B and C overview. To reach plot 399 (this population may be on private land and thus was not included in our cover estimate totals): from origin of plot 1, bearing 178°, ~40m. Near Douglas-fir (*Pseudotsuga menziesii*) with big leaf maple (*Acer macrophyllum*) growing with it, where hill steeply drops off. Population has been captured in a rectangular plot with 14m x 11m sides. Origin is in the NE corner and referenced with conduit (other corners have rebar with yellow caps).

APPENDIX E. LOCATION, DIMENSIONS, AND MONITORING NOTES FOR PLOTS AT OAK BASIN

Appendix E, Table 3. Location, dimensions, and monitoring notes for Kincaid's lupine (*Lupinus oregonus*) and Hitchcock's blue-eyed grass (*Sisyrinchium hitchcockii*; in bold) plots at Oak Basin.

Meadow	Plot Number	Dimensions	origin (Nad27)	Notes
A	7	23m x 12m	504288 E 4906986 N	Measured in 2m increments
A	8	Circular, 2m radius	504259 E 4907001 N	Measured entire plot as one. Fallen log partially on plot.
A	9	18m x 14m	504286 E 4906960 N	Measured in 2m increments
A	10	Circular, 2m radius	504312 E 4906952 N	Measured in 4 quadrats: NW, NE, SW, and SE
A	459	13m x 12m	504246 E 4906964 N	Measured in 3m increments
A	454	20m x 13m	504210 E 4906979 N	Measured in 4m increments. 3 individuals 8m and 48° from origin.
A	464	20m x 26m	504183 E 4906999 N	Measured in 2m increments
A	450	90m x 7m	504232 E 4907030 N	Measured in 5m increments (E-W)
A	451	8m x 7m	504132 E 4906987 N	Measured in 2m increments (N-S)
A	452	25m x 35m	504156 E 4907003 N	Measured in 2m increments
A	460	22m x 16m with extension	504274 E 4906955 N	Measured in 4m increments
A	406	Circular, 2m radius	504101 E 4907056 N	Measured in 4 quadrants: NW, NE, SW, and SE
A	509	Circular, 1.5m radius	504199 E ¹ 4907048N ¹	New in 2011. Measured in 4 quadrats: NW, NE, SW, and SE.
A	510	6m x 10m	503967 E ¹ 4907105 N ¹	New in 2011. Measured in 1m increments N-S; 1m segment measured from E-W.
A	511	3m radius	504702 E ¹ 4907160 N ¹	Changed plot to 4 quadrants (NW, NE, SW, and SE) in 2018
A	369	14m x 12m		New in 2018. Measured in 2m increments N-S.
A	653	16m x 11m	504136 E 4907160 N	New 2019, Measured in 2m segments N-S.
B	1	60m x 18m+	504420 E 4906668 N	Measured in 5m increments

Meadow	Plot Number	Dimensions	origin (Nad27)	Notes
	2	Triangular adjacent to Plot 3	504503 E 4906649 N	Measured entire plot as 1
B	3	12m x 18m (20m)	504514 E 4906646 N	Measured in 2m increments
B	4	Circular, 3m radius	504545 E 4906630 N	Measured in 4 quadrats: NW, NE, SW, and SE
B	5	12m x 9m	504597 E 4906570 N	Measured in 2m increments, except the last, which was 3m
B	6	11m belt transect	504628 E 4906559 N	Measured in 2m increments to each side until last plant
B	399**	11m x 14m-16m plot	504326 E 4906806 N	Measured E-W in 2m increments
B	Plot 2 Tag 558	12m x 6.8m x 13.7m	504413 E ¹ 4906842 N ¹	New in 2014, plot is triangular, directly adjacent to Plot 3.
C	594	12m belt	See map	New in 2017. Measured in 2m increments on each side (N&S).
C	233	1m radius	See map	New in 2017. Measured entire plot as one.
C	1(185) ²	14m belt transect	504639 E ¹ 49065659N ¹	Measured in 1m increments on each side (E&W)
C	2(186) ²	2m radius	504655 E ¹ 4906555N ¹	Measured in 4 quadrats: NW, NE, SW, and SE
C	433	8m belt transect	504712 E 4906379 N	Measured in 2m increments on each side (N&S)
C	432	8m x 9m	504649 E 4906401 N	Measured in 2m increments
C	431	18m belt transect	504732 E 4906378 N	Measured in 1m increments on each side (E & W)
C	400	1m radius	504609 E ¹ 4906553 N ¹	New in 2012; along tree line in <i>Rupertia physodes</i>

¹ Coordinates are in NAD83 instead of NAD27.

² Plots 1 (185) and Plot 2 (186) in Meadow C are SIHI plots.

** There is a large patch of Kincaid's lupine at the SW end of Meadow B, which is on private property. Plot 399 captures the lupine nearest the public/private boundary.

APPENDIX F. LOCATIONS OF KINCAID'S LUPINE PLANTINGS

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Appendix F, Figure 5. Locations of Kincaid's lupine (*Lupinus oreganus*) plantings (orange polygons planted in 2017) on Merzenich property. Survivorship of transplants was monitored in 2018 and 2019.

APPENDIX G. MATURE AND ABORTED RACEMES (2006-2021)

Appendix G, Table 4. Total number of mature racemes and percent racemes aborted of Kincaid's lupine (*Lupinus oreganus*) at Oak Basin from 2006 to 2021.

	Meadow A		Meadow B		Meadow C		Grand Total	
	Mature Racemes	Percent Aborted	Mature Racemes	Percent Aborted	Mature Racemes	Percent Aborted	Mature Racemes	Percent Aborted
2006	245	13%	375	9%	145	6%	765	10%
2007	881	28%	1,482	7%	810	4%	3,173	13%
2008	891	21%	1,027	13%	432	3%	2,350	15%
2009	415	31%	1,004	17%	55	38%	1,474	23%
2010	1,860	5%	1,678	4%	108	28%	3,646	5%
2011	1,978	3%	1,845	3%	192	6%	4,015	3%
2012	1,328	3%	969	2%	127	0%	2,424	3%
2013	71	58%	122	55%	44	46%	237	55%
2014	1,108	4%	627	1%	311	0%	2,046	2%
2015	129	46%	120	35%	177	11%	426	32%
2016	209	2%	197	3%	217	37%	623	18%
2017	1,996	2%	736	3%	881	2%	3,613	2%
2018	1,984	1%	587	2%	471	1%	3,042	1%
2019	2,775	24%	523	26%	1,265	13%	4,563	24%
2020	2,320	8%	815	10%	1,413	4%	4,548	7%
2021	1,403	12%	627	13%	442	13%	2,472	12%

Appendix G, Table 5. Total Kincaid's lupine (*Lupinus oreganus*) cover and number of racemes per m² of Kincaid's lupine foliar cover at Oak Basin from 2006 to 2021.

	Meadow A		Meadow B		Meadow C		All Meadows	
	Cover (m ²)	Mature racemes/m ²	Cover (m ²)	Mature racemes/m ²	Cover (m ²)	Mature racemes/m ²	Cover (m ²)	Mature racemes/m ²
2006	39.3	6	44.9	8	11.5	13	95.7	8
2007	37.3	24	37.7	39	21.1	38	96.1	33
2008	45.3	20	45.9	22	10.6	41	101.8	23
2009	49.5	8	50.1	20	10.7	5	110.3	13
2010	65.3	28	49.6	34	12.0	9	126.9	29
2011	86.8	23	60.3	31	15.2	13	162.3	25
2012	86.5	15	70.0	14	13.6	9	170.1	14
2013	42.9	2	25.5	5	11.2	4	79.6	3
2014	80.4	14	51.6	12	17.8	17	149.8	14
2015	49.2	3	21.4	6	21.7	8	92.3	5
2016	47.3	4	18.9	10	14.0	15	80.2	8
2017	87.5	23	34.7	21	29.5	30	151.7	24
2018	110.3	18	27.9	21	25.2	19	163.4	19
2019	105.5	26	27.4	19	35.6	36	168.5	27
2020	120.8	19	40.0	20	31.1	45	192.3	24
2021	106.6	13	35.3	18	23.1	19	164.9	15

APPENDIX H. *SISYRINCHIUM HITCHCOCKII* SIZE CLASS AND REPRODUCTIVE SUMMARY

Appendix H, Table 6. Count of number of Hitchcock's blue-eyed grass (*Sisyrinchium hitchcockii*) stems by size class in Meadow C at Oak Basin from 2012 to 2020. "R" numbers represent the number of inflorescences recorded per stem (R1, R2, R3, etc.).

Size Class	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Vegetative	42	47	26	44	30	15	17	18	11	26
R1	55	40	17	13	8	21	12	17	29	14
R2	14	10	9	5	2	20	10	9	19	22
R3	7	5	5	1	1	8	4	15	15	5
R4	1	1	7	0	1	1	1	3	8	0
R5	1	1	0	1	0	1	1	1	6	0
R6	1	0	12	0	0	0	0	0	3	0
R7	0	0	7	0	0	0	0	1	2	0
R8	0	1	0	0	0	0	0	0	0	0
R9	1	0	0	0	0	0	0	1	0	0
R10	0	0	0	0	0	0	0	1	1	0
R11	0	0	0	0	0	0	0	1	1	0
R12	0	0	1	0	0	0	0	1	0	0
R13	0	0	0	0	0	0	0	0	0	0
R14	0	0	1	0	0	0	0	1	0	0
R19	0	0	0	0	0	0	1	0	0	0
R21	0	0	0	0	0	0	0	1	0	0
Total Reproductive Individuals	80	58	59	20	12	51	29	52	84	21
Total Reproductive Stems	128	92	225	31	19	89	72	160	206	33
Total number of plants	122	105	85	64	42	66	46	70	95	47

APPENDIX I. HABITAT QUALITY SPECIES LISTS

Relevé plots were surveyed on June 30, 2020 and will be surveyed on a biennial basis.

	Meadow (plot #)		
	A (696)	B (691)	C (690)
Non-native forbs	<i>Cerastium glomeratum</i> <i>Dianthus armeria</i> <i>Galium parisiense</i> <i>Hypericum perforatum</i> <i>Leucanthemum vulgare</i> <i>Linum bienne</i> <i>Myosotis discolor</i> <i>Plantago lanceolata</i> <i>Sherardia arvense</i> <i>Taraxicum officinale</i> <i>Tragopogon dubius</i> <i>Comandra umbellata</i> <i>Veronica arvensis</i>	<i>Cerastium glomeratum</i> <i>Geranium dissectum</i> <i>Hypericum perforatum</i> <i>Leucanthemum vulgare</i> <i>Linum bienne</i> <i>Medicago lupulina</i> <i>Plantago lanceolata</i> <i>Prunella vulgaris</i> <i>Rumex acetosella</i> <i>Sherardia arvense</i> <i>Torilis arvensis</i> <i>Tragopogon dubius</i> <i>Unk. forb 1</i> <i>Vicia sativa</i>	<i>Centaurium erythraea</i> <i>Dianthus armeria</i> <i>Geranium dissectum</i> <i>Hypericum perforatum</i> <i>Hypochaeris radicata</i> <i>Leucanthemum vulgare</i> <i>Linum bienne</i> <i>Lotus micranthus</i> <i>Medicago lupulina</i> <i>Plantago lanceolata</i> <i>Sherardia arvense</i> <i>Torilis arvensis</i> <i>Veronica arvensis</i> <i>Vicia sativa</i>
Native forbs	<i>Achillea millefolium</i> <i>Brodiaea coronaria</i> <i>Calochortus tolmei</i> <i>Clarkia amoena</i> <i>Clarkia purpurea</i> <i>Eriophyllum lanatum</i> <i>Fragaria virginiana</i> <i>Leptosiphon bicolor</i> <i>Madia gracilis</i>	<i>Achillea millefolium</i> <i>Clarkia amoena</i> <i>Dichelostemma capitatum</i> <i>Eriophyllum lanatum</i> <i>Fragaria vesca</i> <i>Fragaria virginiana</i> <i>Iris tenax</i> <i>Viola nuttallii</i>	<i>Achillea millefolium</i> <i>Balsamorhiza sagittata</i> <i>Calochortus tolmei</i> <i>Clarkia amoena</i> <i>Eriophyllum lanatum</i> <i>Fragaria virginiana</i> <i>Madia elegans</i> <i>Polygonum sp.</i> <i>Potentilla gracilis</i> <i>Ranunculus occidentalis</i>

Non-native graminoids	<i>Agrostis capillaris</i> <i>Aira caryophylla</i> <i>Bromus hordeaceus</i> <i>Bromus sterilis</i> <i>Cynosurus echinatus</i> <i>Dactylis glomerata</i> <i>Schedonorus arundinaceae</i> <i>Vulpia bromoides</i>	<i>Agrostis capillaris</i> <i>Aira caryophylla</i> <i>Bromus hordeaceus</i> <i>Bromus sterilis</i> <i>Cynosurus echinatus</i> <i>Dactylis glomerata</i> <i>Phleum pratense</i> <i>Schedonorus arundinaceae</i> <i>Vulpia bromoides</i>	<i>Agrostis capillaris</i> <i>Briza minor</i> <i>Bromus hordeaceus</i> <i>Cynosurus echinatus</i> <i>Dactylis glomerata</i> <i>Holcus lanatus</i> <i>Phleum pratense</i> <i>Schedonorus arundinaceae</i> <i>Taeniatherum caput-medusae</i>
Native graminoids	<i>Bromus carinatus</i> <i>Danthonia californica</i> <i>Elymus trachycaulus</i> <i>Festuca roemerii</i> <i>Koeleria macrantha</i> <i>Luzula comosa</i>	<i>Bromus carinatus</i> <i>Danthonia californica</i> <i>Elymus glaucus</i> <i>Luzula comosa</i>	<i>Bromus carinatus</i> <i>Danthonia californica</i> <i>Elymus glaucus</i> <i>Elymus trachycaulus</i> <i>Festuca roemerii</i> <i>Luzula comosa</i>
Shrub/tree		<i>Crataegus suksdorfii</i> <i>Quercus garryana</i>	

APPENDIX J. CONTACTS, DIRECTIONS, AND GEAR LIST FOR OAK BASIN

Private landowner contact (access is through his property, but you do not need to contact)

Jim Merzenich

Oak Basin Tree Farm

7410 Oleson Road, PMB #319

Portland, OR 97223

m: (503) 799-6772

jim@oakbasin.com

To Oak Basin

To Meadows A, B, and C

Heading south on I-5 from Corvallis, take exit 216.

Head east towards Brownsville. Turn right (at Chevron Station) onto Washburn Road, which will become Gap Road.

Turn left onto Northernwood Rd. (5.8 miles from the freeway).

Reset the mileage as you turn onto Northernwood Rd.

At the end of Northernwood Rd., the road turns to gravel and forks.

Take the left-gated fork (use key if necessary). (0.7 miles)

At 1.0 miles stay right (don't go to the barn/equipment area).

At 1.2 miles go right.

At 1.6 miles go right (road is grassier and rough).

Park at 2.3 miles and walk up the road to the base of Meadow A.

See maps and photos for directions to meadows.

To Doghead Meadow

Drive south on I-5 to Brownsville/Hwy 228 exit (exit 216).

Take Highway 228 east, just over 6 miles, to Courtney Creek Road.

(Start mileage once turning onto Courtney Creek Road.)

Courtney Creek Road becomes Timber Road at ~2.5 miles.

Continue past gravel pile (on left) for a total of 7.3 miles.

Park at (mostly) blocked road, 14-2.34 (signed). Walk in to the end of the road (~1.5 to 2 miles).

Follow old ATV trail to the right through trees to meadow (flagged and sign saying no motorized traffic).

Equipment needed:

Eugene BLM Key for Oak Basin Site

Data sheets

Last year's report

Last year's data

Maps and Gazetteer

Rulers – 1 per person

2 tatums and extra pencils

Meter tapes: Minimum 6 tapes (more is better: at least 3 three 100m tapes)

1m² plot frame (for community monitoring)

1m poles – 2 per person (for measuring/sectioning large patches)

Candy canes (at least 2x the number of tapes)

Pin flags – white (for marking lupine), pink (for marking plot corners), other color (for various other uses)

Compass

Flagging

Rebar, conduit, or fiberglass x3 (for replacement, if necessary)

Plot tags and wires x3 (for replacement, if necessary)

Extra water

Health and Safety Box

Tecnu

First aid kit