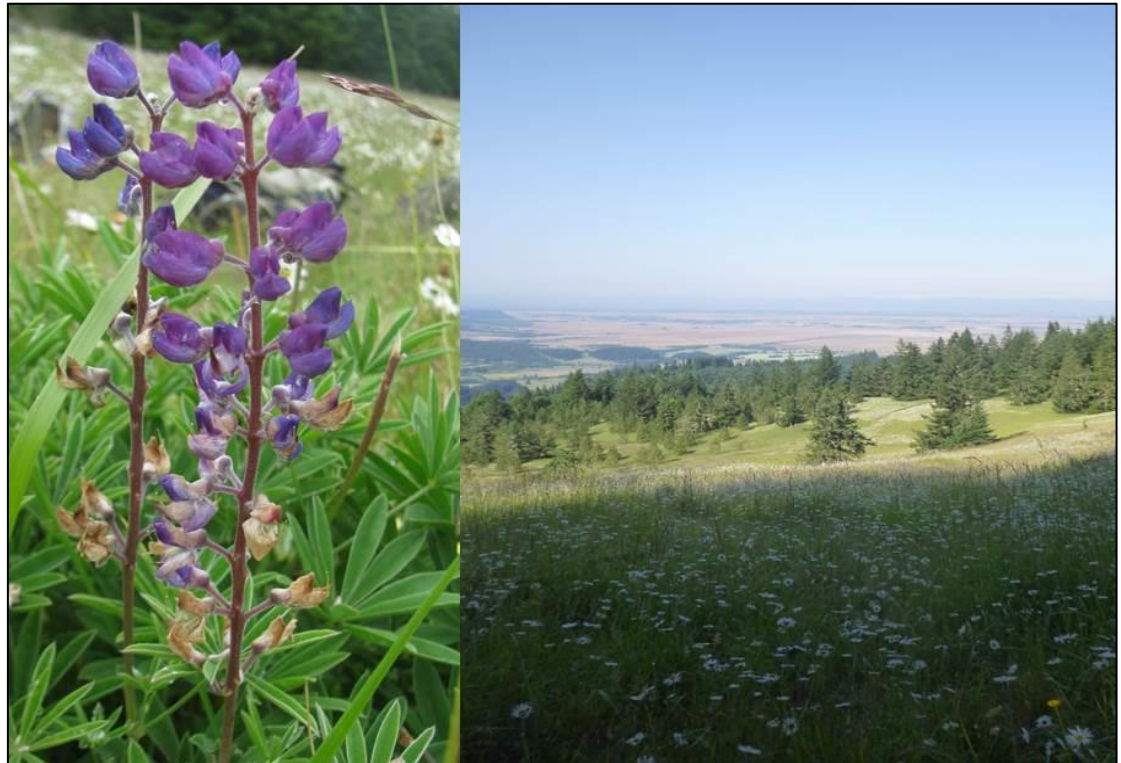


Monitoring and restoration of Kincaid's lupine (*Lupinus oreganus*) and Hitchcock's blue-eyed grass (*Sisyrinchium hitchcockii*) at Oak Basin: 2020 Annual Report



2/28/2021

Report to the Bureau of Land Management, Upper Willamette Resource Area: Northwest Oregon District, L16AC00241 and L18AC00073

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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: Kincaid's lupine (*Lupinus oreganus*) and Oak Basin Meadow A.

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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 (BLM) at Oak Basin, an upland prairie managed by the BLM's. This site 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 on BLM lands at Oak Basin has been on the decline since 2015 and only 24 individuals were documented in 2020. All three species are endemic to western Oregon prairies.

Management treatments

Management treatments conducted in 2020 included mowing Kincaid's lupine patches to reduce invasive perennial grass and shrub cover, flame weeding experimental plots and non-native grass patches adjacent to Kincaid's lupine, removal of conifers between meadow corridors to increase meadow connectivity and reduce woody encroachment around Kincaid's lupine patches, and hand pulling or grubbing noxious weeds, including Himalayan blackberry (*Rubus bifrons*), Scotch broom (*Cytisus scoparius*), and Italian plumeless thistle (*Carduus pycnocephalus*).

Kincaid's lupine

In 2020, total Kincaid's lupine foliar cover at Oak Basin was 192.3 m², the highest foliar cover documented since monitoring began in 2006 and continuing the positive trend that started in 2016. In 2020, the count of mature racemes was 4,548, which was on par with 2019's count, the highest (4,563 racemes) since 2006. 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.

Hitchcock's blue-eyed grass

The number of Hitchcock's blue-eyed grass individuals and reproductive stems at Oak Basin's Meadow C have increased since 2016. In 2020, 206 reproductive stems were observed (the count has ranged from 19-225 from 2012-2020), and 84 reproductive individuals (the highest count since 2012). Hitchcock's blue-eyed grass and Kincaid's lupine have followed roughly parallel trajectories in population size at Oak Basin, both declining from 2012 to 2016 and generally increasing from 2016 to the present.

Recommendations

Based on effects of management actions and the importance of this site for reaching recovery goals for Fender's blue butterfly and Kincaid's lupine, continued management for introduced species, particularly introduced perennial and annual graminoids is recommended. Activities in 2021 should include continued control of introduced species and tree removal around the forest-meadow edge and in corridors to increase connectivity between meadows. We recommend that the meadows and especially the corridors between meadows be treated for weeds using all available tools (herbicide, fire, mechanical, etc.), followed by seeding and planting treated areas with a mix of native nectar species and perennial grasses.

Monitoring and restoration of Kincaid's lupine (*Lupinus oreganus*) and Hitchcock's blue-eyed grass (*Sisyrinchium hitchcockii*) at Oak Basin: 2020 Annual Report

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 2020. Oak Basin, a site managed by the Upper Willamette Field Office in the Northwest Oregon District of the Bureau of Land Management (BLM) is approximately six miles southeast of Brownsville, Oregon. The site includes upland prairie, oak (*Quercus garryana*), maple (*Acer macrophyllum*), and Douglas-fir (*Pseudotsuga menziesii*) woodlands. Oak Basin supports the largest known Kincaid's lupine (*Lupinus oreganus*; Figure 1) population in the Upper Willamette Field Office, 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 24 butterflies documented in 2020 (Menke 2021), and it remains vulnerable to complete sub-population collapse and extirpation.

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 population of the rare Hitchcock's blue-eyed grass (*Sisyrinchium hitchcockii*) to document population trends.



FIGURE 1. KINCAID'S LUPINE (*LUPINUS OREGANUS*, TOP) AND FENDER'S BLUE BUTTERFLY (*ICARICIA ICARIOIDES FENDERI*, BOTTOM).

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. This 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 primary host for the federally endangered Fender's blue butterfly larvae (Oregon Biodiversity Information Center 2016), conservation of Kincaid's lupine populations is a common 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 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). This 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 (C) FLOWERS HAVE BLUE TO BLUISH-PURPLE TEPALS WITH A FAINT (OR ABSENT) YELLOW "EYE" IN CENTER.

Oak Basin has been identified as a potential Functioning Network to meet the downlisting goals for Fender's blue butterfly. The site also contributes to the recovery of Kincaid's lupine; the population currently meets the minimum local foliar cover of 100 m² needed for the site to count towards recovery (U.S. Fish and Wildlife Service 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 are mature adults in May and June; this is when they fly, eat 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 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, when they crawl under nearby vegetation and plant litter and enter diapause. They remain in a dormant state until February or early March when they begin feeding again on the newly emerging Kincaid lupine leaves. Near the end of April they pupate and reemerge as butterflies (Schultz and Crone 1998).

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 increasing, with area of foliar cover being maintained at or above the minimum targets as laid out in the Recovery Plan (U.S. Fish and Wildlife Service 2010). A second objective is to assess the status of the Hitchcock's blue-eyed grass population and to help guide restoration activities therein. 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. This zone has a target of supporting at least two populations with total foliar cover of 5000 m².
- Kincaid's lupine populations must show evidence of reproduction by seed set or through 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 such 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:

1. Maintain/improve quality prairie habitat by removing non-native invasive plants;
2. Prevent encroachment of woody species into the prairie;
3. Increase diversity and abundance of the native plant community; and
4. Improve connectivity between meadows at Oak Basin.

METHODS

Monitoring methods

Habitat quality

In 2020, new monitoring methods were employed at Oak Basin so that habitat quality data are now directly applicable to habitat quality criteria measurements 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 invasive species and plant management groups, were calculated.

Restoration experiment

In addition to the relevé plots, in 2020 a new experimental restoration project was installed to assess the efficacy of utilizing a combination(s) of mowing, grass specific herbicide, fire, glyphosate, and seeding over time (one, two, and four years after treatment). 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 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 will be included as a control.

A total of 10 experimental plots (10m x 30 m) were established in occupied Kincaid's lupine habitat in the 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 will be collected from four 1m² quadrats randomly placed within each of the subplots in June. Percent cover will be 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 will be taken from the south, central edge of the plot before sampling of the quadrats.

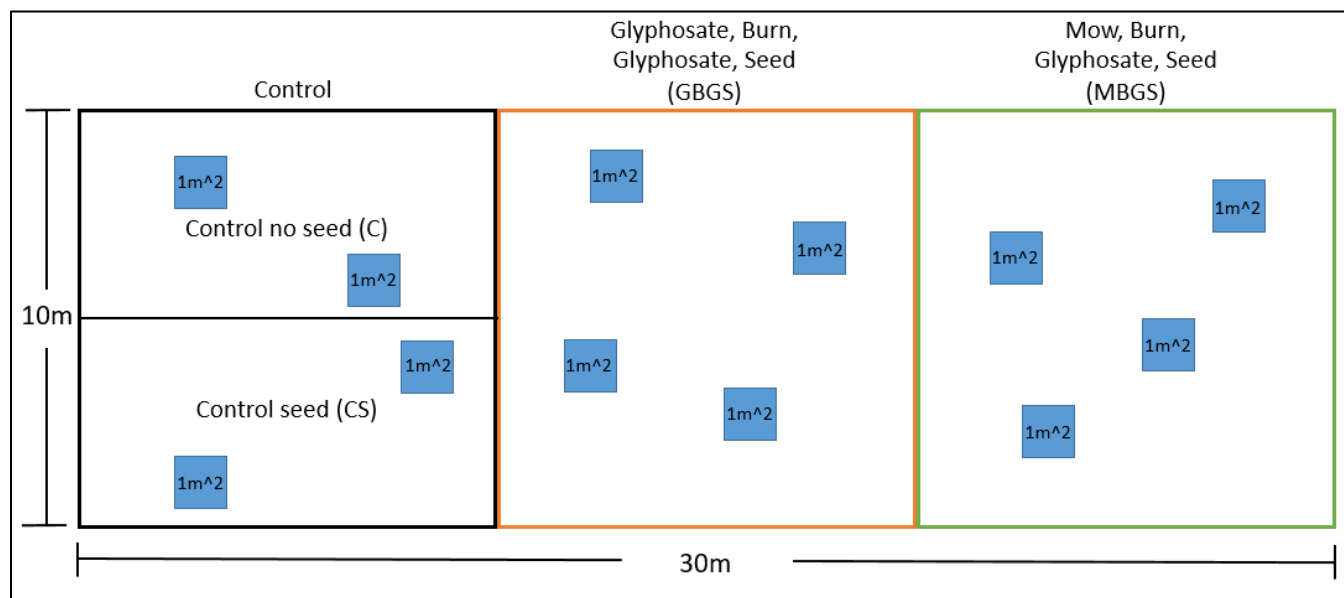


FIGURE 3. DIAGRAM OF OAK BASIN EXPERIMENTAL DESIGN. ONE PLOT IS 10M X 30M. PLOTS ARE DIVIDED INTO THREE SUBPLOTS (10M X 10M). EACH SUBPLOT HAS A TREATMENT: CONTROL, GBGS (GLYPHOSATE-FLAME WEED-GLYPHOSATE-SEED), OR MBGS (MOW-FLAME WEED-GLYPHOSATE-SEED). THE CONTROL IS DIVIDED FURTHER INTO TWO SUBPLOTS: ONE SEEDED, ONE LEFT UNSEEDED. EACH SUBPLOT WAS SAMPLED BY VISUALLY ESTIMATING SPECIES AND GROUND COVER TYPES IN FOUR 1M² QUADRATS.

Kincaid's lupine

Kincaid's lupine monitoring 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 established around Kincaid's lupine patches. Additional plots have been added as new patches have been located. Larger plots are rectangular and marked with fiberglass posts, rebar, or conduit in 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 C Figure 3 and Appendix C 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 (U.S. Fish and Wildlife Service 2010). The percentage of aborted racemes is calculated by dividing the number of aborted racemes by the sum of 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 2020. 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 (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.

Habitat restoration

In 2020, IAE coordinated and implemented a variety of activities to support restoration and conservation efforts in Meadows A, B and C (Table 1, Figure 4 and Figure 5). Restoration actions included flame weeding several key areas, grubbing Himalayan blackberry (*Rubus bifrons*) and Scotch broom (*Cytisus scoparius*), hand pulling Italian plumeless thistle (*Carduus pycnocephalus*), mowing in Kincaid's lupine patches, removing conifers between Meadows B and C and from around oaks in Meadow C, and seeding in areas disturbed by tree removal activities. Appendix A includes a summary of restoration activities conducted at Oak Basin from 2012 to 2020.

TABLE 1. HABITAT RESTORATION ACTIVITIES COMPLETED AT OAK BASIN IN 2020.

Date	Activity	Who
1/15/20	Initial site visit for the year and meeting with BLM staff to discuss a potential prescribed burn at the site.	IAE and BLM
4/22/20	Created plot markers for establishing experimental plots.	IAE
4/23/20	- Seed collection scouting for SOS program - Tree removal between Meadows B and C for corridor creation.	IAE

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Date	Activity	Who
5/28/20	- Hand pulled Italian plumeless thistle from two populations in Meadow B. Could not find any Italian thistle plants in Meadow A patch. - Pulled Scotch broom in Meadow A. - Grubbed Himalayan blackberry in Meadow C.	IAE
6/16/20	Installed plot markers and took photo points of new experimental plots.	IAE
7/24/20 and 8/7/20	East Eugene Kincaid's lupine seed collection at Oak Basin and Eagle's Rest.	IAE
10/8/20 and 10/9/20	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.	IAE and Walama Restoration Project
10/21/20 and 10/22/20	- Spot sprayed non-native species in all experimental plots with glyphosate. - Cut and limbed one large tree from the corridor on private land between Meadows A and B.	IAE
11/4/20	- Grubbed Himalayan blackberry patches in Meadows B and C. - 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. - Retook photo points of experimental plots in Meadows A and B.	IAE, Americorp Blue Team 4 and Walama Restoration Project
11/5/20	- Flame weeded experimental plots in Meadow C. It was a very misty day and therefore flame weeding was inefficient. Activity approved by BLM fire duty officer Sean Sheldon. - Bucked and piled tree felled in October between Meadows A and B. - Broadcast a seed mix into flame weeded patches A5 and A6 .	IAE, Americorp Blue Team 4 and Walama Restoration Project
11/16/20	Flame weeded the last of the experimental plots in Meadow B. Activity approved by BLM fire duty officer Sean Sheldon.	IAE and Walama Restoration Project
12/2/20	Approximately 35 conifer trees between one and 20 inches DBH were cut near Oregon white oaks and along the forest/meadow edge in Meadow C. The woody material was scattered into the adjacent forests. Approximately four oaks that were being crowded by conifers were released.	IAE and Americorps Blue Team 4

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FIGURE 4. MANAGEMENT ACTIONS COMPLETED IN MEADOW A AT OAK BASIN IN 2020.

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FIGURE 5. MANAGEMENT ACTIONS COMPLETED IN MEADOWS B AND C AT OAK BASIN IN 2020.

Mowing

On October 8 and 9, 2020 the area in and around seven Kincaid's lupine patches was mowed using a string trimmer to reduce standing thatch and to remove competing non-native perennial grasses (Figure 4, Figure 5 and Figure 6). The goal is to mow competing vegetation within approximately 1/3 of the area occupied by Kincaid's lupine in each of the three meadows annually; these patches rotate 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. In addition, as part of the newly established restoration experiment, one subplot within the 10 experimental plots (MBGS, Figure 3) was mowed in all meadows (Figure 4 and Figure 5).



FIGURE 6. KINCAID'S LUPINE (*LUPINUS OREGANUS*) PATCH #1 IN MEADOW B BEFORE MOWING (LEFT) AND AFTER MOWING (RIGHT). PHOTO BY JESSICA CELIS.

Hand pulling of weeds

IAE staff and the AmeriCorps Blue Team 4 hand pulled several invasive species at Oak Basin, including Himalayan blackberry, Scotch broom and Italian plumeless thistle (

Table 1). Three patches of Himalayan blackberry were grubbed out of Meadows B and C using shovels. One patch in Meadow B overlaps with Kincaid's lupine patch 001 and has been grubbed annually since 2013. Individual Kincaid's lupine plants in patch 001 are marked with pin flags to allow grubbing to occur while avoiding damage to the Kincaid's lupine. In Meadow A, Scotch broom was hand pulled (Figure 4). In Meadow B, two patches of Italian plumeless thistle were hand pulled. The eastern patch of Italian plumeless thistle was newly discovered this year and should be monitored and treated annually before plants flower and set seed (Figure 5).

Flame weeding

A total of 0.80 acre was flame weeded on November 4 and 5, 2020 (Table 1). Two patches of dense annual and perennial grass in Meadow A (A5 and A6) and two subplots (200 m²) in each of the 10 experimental plots were flame weeded (Figure 4, Figure 5 and Figure 7).



FIGURE 7. ANNUAL GRASS PATCH FOLLOWING FLAME WEEDING ON NOVEMBER 5, 2020. PHOTO IS LOOKING TOWARD THE CORRIDOR BETWEEN MEADOWS A AND B. PHOTO BY JESSICA CELIS.

Tree removal

Through a coordinated planning effort between the BLM, Oak Basin Tree Farm and IAE in 2019, conifers were removed that were blocking light and preventing easy access for Fender's blue butterfly between meadows A and B (Figure 8). In 2020, IAE further improved this corridor by removing a large conifer that was blocking the corridor (Figure 8). Subsequently, the AmeriCorps Blue Team 4 and IAE staff spent one day removing all the fallen tree debris by piling branches and leaves into the middle of the corridor and moving larger bucked rounds into the forest.

On December 2, approximately 35 conifer trees with a diameter at breast height (DBH) between one and 20 inches were cut near Oregon white oaks and along the forest/meadow edge in Meadow C. The woody material was scattered into the adjacent forest. Approximately four oaks that were being crowded by conifers were released. On December 12, IAE staff completed piling efforts in Meadow B and broadcast seed into areas disturbed by tree removal activities. In addition, conifer seedlings and saplings were cut from the north and east edges of Meadow A and along the entire edge of Meadow C.



FIGURE 8. BEFORE (LEFT) AND AFTER (RIGHT) TREE REMOVAL IN THE CORRIDOR BETWEEN MEADOWS A AND B. PHOTOS BY JESSICA CELIS.

Seed collection

Kincaid's lupine seed was wild-collected from Oak Basin (from both BLM land and adjacent private land) in late July and from Eagle's Rest in early August.

In addition, IAE staff wild-collected seed of other native species at Oak Basin and Eagle's Rest. Species collected included common yarrow (*Achillea millefolium*), California brome (*Bromus carinatus*), California fescue (*Festuca californica*), bluehead gilia (*Gilia capitata*), tough-leaved iris (*Iris tenax*), spring gold

(*Lomatium utriculatum*), western buttercup (*Ranunculus occidentalis*), and narrowleaf mule's ear (*Wyethia angustifolia*). Collected seed will either be submitted to the Seeds of Success (SOS) program or reserved for seed amplification, plug growout or direct seeding in support of restoration efforts.

Seeding

On November 5, 2020 a total of 10.75 lbs of native grass and forb seed mix was broadcast onto flame weeded patches A5 and A6 (Figures 4 and 5).

TABLE 2. SPECIES SEEDED IN THOSE AREAS DISTURBED BY TREE REMOVAL ACTIVITIES ON NOVEMBER 5, 2020.

Species	Growth form	Quantity (lbs)
<i>Danthonia californica</i>	Graminoid	5.60
<i>Eriophyllum lanatum</i>	Forb	0.62
<i>Festuca roemerii</i>	Graminoid	1.57
<i>Plectritis congesta</i>	Forb	1.05
<i>Sidalcea malviflora</i> ssp. <i>virgata</i>	Forb	1.92

RESULTS

Habitat quality

In each meadow, a 25 m² relevé plot was permanently installed and surveyed for species richness. Observations are summarized in Table 3. A full list of observed species is provided in Appendix H.

TABLE 3. NUMBER OF SPECIES OBSERVED WITHIN A 5 X 5 M PLOT IN EACH MEADOW, SUMMARIZED BY PLANT MANAGEMENT GROUP AND NATIVITY.

	Number of species observed							
	Forbs		Graminoids		Tree/Shrubs		Total	
	Native	Non-native	Native	Non-native	Native	Non-native	Native	Non-native
Meadow								
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							15	23

Experimental plots

In 2020, 10 experimental plots were installed for a restoration research project. A brief summary of the baseline community data is given here.

Monitoring and restoration of Kincaid's lupine (*Lupinus oreganus*) and Hitchcock's blue-eyed grass (*Sisyrinchium hitchcockii*)
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TABLE 4. MEAN GROUND TYPE COVER (%) FOR EACH EXPERIMENTAL PLOT AND EACH MEADOW. EACH EXPERIMENTAL PLOT CONTAINS 12, 1X1M SUBPLOTS IN WHICH PERCENT COVER WAS VISUALLY ESTIMATED FOR ALL GROUND TYPES.

Meadow and Plot	Mean % cover				
	Bare ground	Litter	Moss	Rock	Basal vegetation
A	0.7	60.5	1.6	0.1	37.8
1	0.8	56.9	0.8	0.0	41.7
2	1.2	63.5	2.0	0.4	33.6
3	0.3	66.0	1.2	0.0	34.2
4	0.3	55.8	2.3	0.0	41.6
B	1.4	61.2	4.4	0.2	32.9
1	2.4	61.1	1.1	0.4	35.0
2	0.3	57.3	11.8	0.1	30.
3	1.5	65.3	0.2	0.2	32.9
C	0.7	62.1	8.2	0.7	28.6
1	0.1	63.2	0.2	0.5	36.3
2	1.6	65.2	1.2	0.9	31.7
3	0.2	58.1	23.1	0.6	18.0
All meadows	0.9	61.2	4.4	0.3	33.5

TABLE 5. MEAN PLANT MANAGEMENT GROUP COVER (%) FOR EACH EXPERIMENTAL PLOT AND EACH MEADOW. EACH EXPERIMENTAL PLOT CONTAINS 12, 1X1M SUBPLOTS IN WHICH PERCENT COVER WAS VISUALLY ESTIMATED FOR ALL SPECIES.

Meadow and Plot	Mean % cover					
	Native Forb	Invasive Forb	Native Graminoid	Invasive Graminoid	Native Tree/Shrub	Invasive Tree/Shrub
A	16.3	15.9	1.8	53.6	9.0	2.1
1	12.4	14.5	1.1	52.8	11.1	2.7
2	16.5	24.0	1.7	42.1	>0.1	0.1
3	9.9	10.3	3.0	65.8	11.6	4.9
4	26.3	14.8	1.4	53.9	13.2	0.7
B	15.2	17.8	1.3	43.5	11.8	0.4
1	18.0	21.6	0.9	29.7	23.0	0.2
2	13.2	8.1	1.0	45.9	12.3	1.0
3	14.6	23.8	2.2	54.8	>0.1	0.0
C	13.7	14.6	3.5	45.4	3.0	1.6
1	4.1	28.2	7.1	70.0	0.0	0.0
2	22.3	9.6	1.8	45.5	0.1	0.0
3	14.7	5.8	1.6	20.5	8.8	4.7
All meadows	15.2	16.1	2.2	48.1	8.0	1.4

Kincaid's lupine

In 2020, total Kincaid's lupine foliar cover was 192.3m² across all meadows (Figure 9,

Appendix F Table 4), there were 4,548 mature racemes, and 96 aborted racemes (Figure 10, Appendix F Table 3). 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 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 were observed.

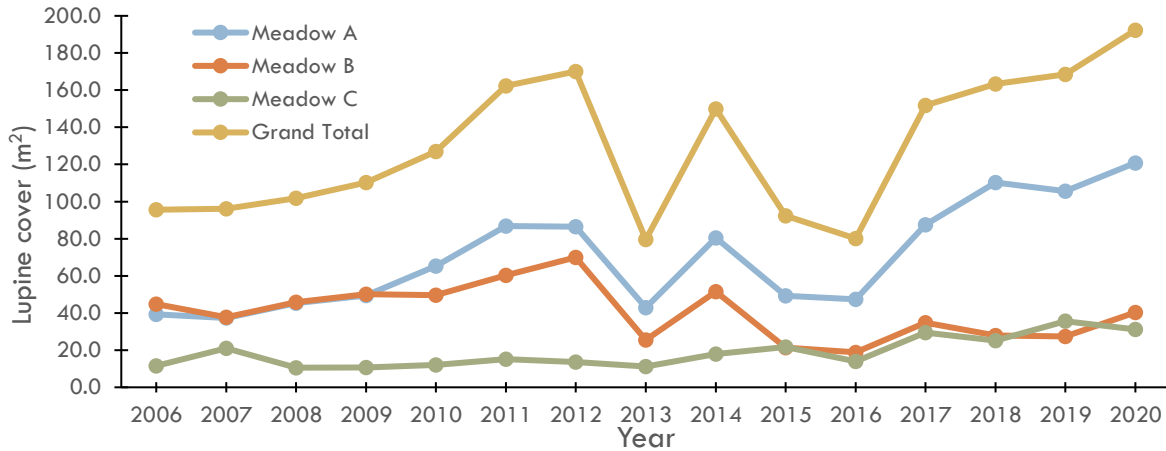


FIGURE 9. KINCAID'S LUPINE (*LUPINUS OREGANUS*) FOLIAR COVER (M²) IN EACH MEADOW AND TOTAL COVER FOR ALL MEADOWS AT OAK BASIN FROM 2006 TO 2020.

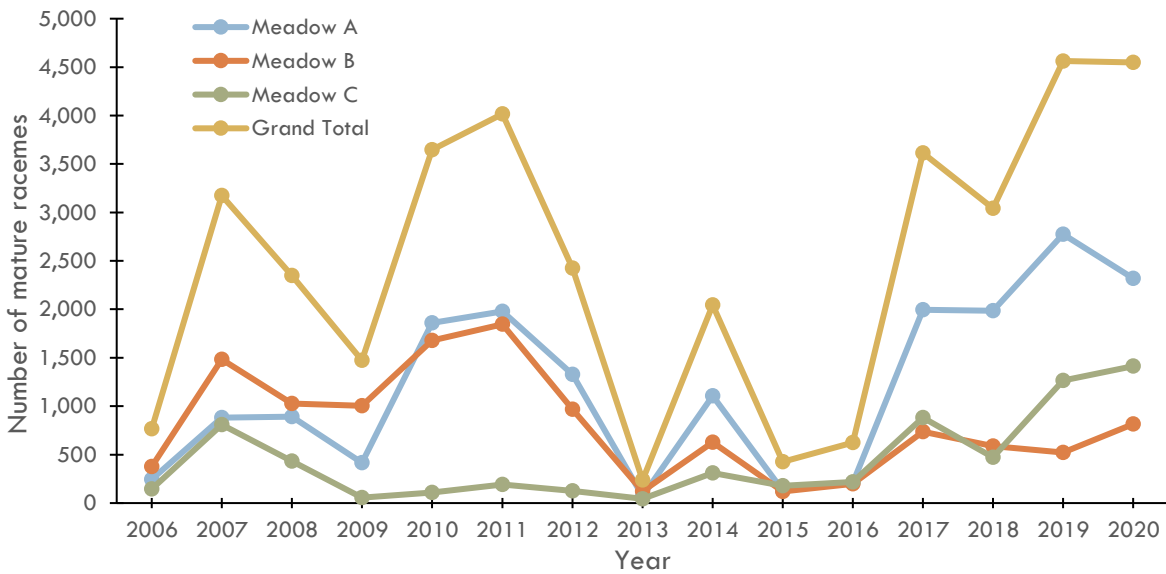


FIGURE 10. TOTAL MATURE KINCAID'S LUPINE (*LUPINUS OREGANUS*) RACEMES COUNTED IN EACH MEADOW AT OAK BASIN FROM 2006 TO 2020.

Hitchcock's blue-eyed grass

In 2020, a total of 95 Hitchcock's blue-eyed grass plants were observed, with a total of 227 reproductive stems (Figure 11). This was the second highest count since monitoring of this species began in 2012, and continues the increasing trend started in 2018. As in previous years, most plants observed in the 4-meter-wide belt transect were found within two meters of the transect tape.

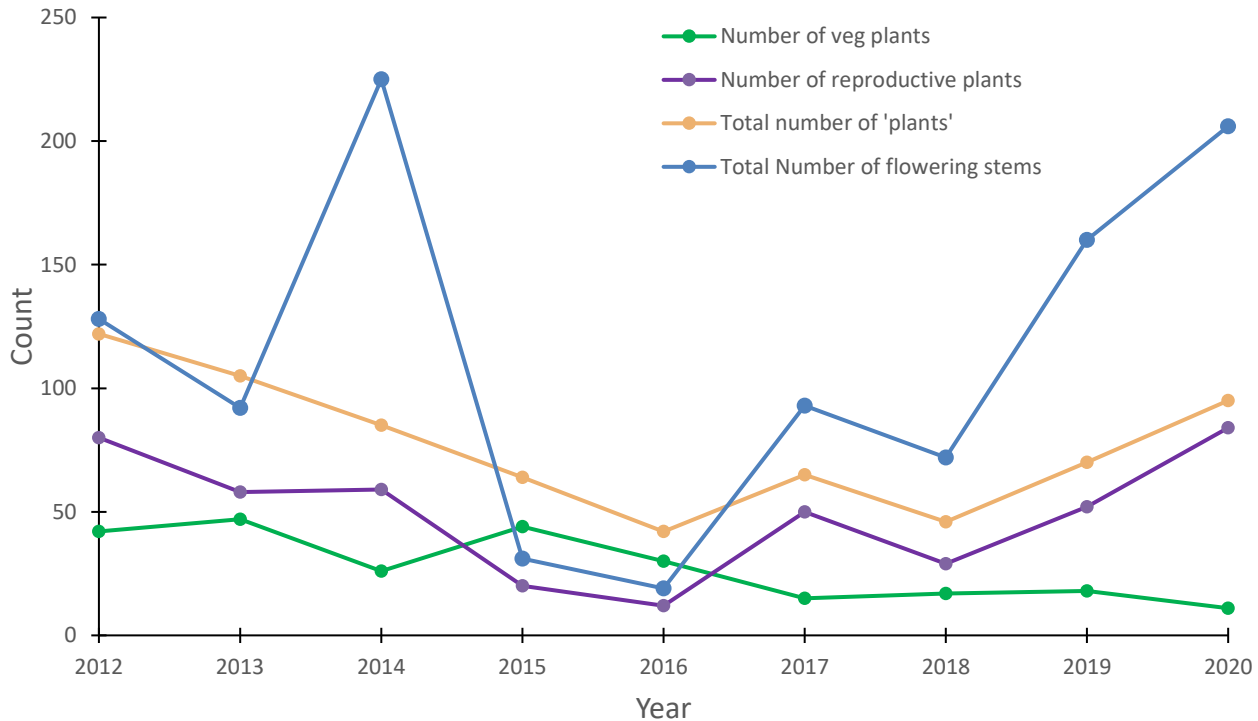


FIGURE 11. POPULATION TRENDS FOR HITCHCOCK'S BLUE-EYED GRASS (*SISYRINCHIUM HITCHCOCKII*) IN MEADOW C AT OAK BASIN FROM 2012 TO 2020.

Kincaid's lupine seed collection

The total amount of wild seed collected from Oak Basin and Eagle's Rest was 0.60g and 11.40g, respectively. The seed will be used for growing plug that will be planted in an established Eugene East seed amplification bed at the IAE farm in spring of 2021.

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 – 192.3.1m², raceme count ranging from 237- 4,563) (Appendix F Table 3 and Appendix F Table 4). Some of these fluctuations could be linked to climatic stresses; for instance, 2015 and 2016 had high temperatures and drought conditions and we observed low cover and raceme counts in those years. However, a number of potential factors, including habitat management (removal of introduced grasses, 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 increased from 2016 to the present.

The total number of racemes has followed a similar pattern to lupine foliar cover at Oak Basin (Figure 9, Figure 10). The 2013 season marked a low point in both raceme production and lupine cover; management actions were initiated in the fall of 2013, and have continued through 2020. As with foliar cover, climate differences, competition from exotic species, 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 the amount of flower production) through the duration of the flight period for Fender's blue butterfly to thrive (Giles-Johnson et al. 2011); this could also be true for other pollinators.

Hitchcock's blue-eyed grass

Over the past eight 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 which are then counted as one during monitoring. Despite the potential limitations of the sampling method in regards 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, increasing in 2020 to the second highest recorded count (Figure 11, Appendix G Table 5). 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 population. (Figure 11).

Synthesis

In order to reach recovery goals for Kincaid's lupine, continued monitoring of both this species and the 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 community continues to pose a great challenge for 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've summarized data for 2020 in Table 6 to compare current conditions to the habitat quality targets listed in the Recovery Plan (U.S. Fish and Wildlife Service 2010).

TABLE 6. SUMMARY OF CURRENT OAK BASIN PRAIRIE HABITAT QUALITY COMPARED TO RECOVERY GOALS. TRENDS SUMMARIZE 14 YEARS OF POPULATION AND COMMUNITY MONITORING DATA FROM 2006 TO 2020.

Prairie Quality and Diversity Summary*			
Criteria	Data	Recovery Plan threshold*	Meets Recovery Plan objectives?
Fender's blue butterfly population size**	BLM land: 24 Private land: 0	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	5000 m ² in Eugene East Recovery Zone, minimum of 100m ² in each meadow to count towards recovery	No
Evidence of reproduction	7.18 g seed collected on BLM land only	Seedset or presence of seedlings	Yes
Native herbaceous species 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 Menke 2000.

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 as well as 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 this, 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 combating 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 this and other non-native species. These treated areas would need to be subsequently seeded and outplanted 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 this site by continuing to hand-pull small, isolated noxious weed populations such as Scotch broom, Himalayan blackberry, and Italian plumeless thistle. Additionally, conifer recruitment should be addressed early by lopping seedlings and saplings rather than allowing trees to grow in size. To address the problem of low Fender's blue butterfly counts at the site, we recommend that particular effort go into increasing meadow connectivity between all BLM owned meadows (A, B, and C) and those located on Oak Basin Tree Farm through the creation of corridors. These corridors need to be heavily treated for the forest-adapted and non-native species that dominate the herbaceous understory and subsequently seeded heavily with those species that the Fender's blue butterfly use.

The following habitat management, monitoring activities, and recovery actions are recommended at Oak Basin in 2021 and beyond:

- Continue to treat non-native species using all available methods, including spot spraying non-native perennial species with herbicide.
 - Hand pull all populations of Italian thistle annually.
 - Spot spray Himalayan blackberry in all meadows.
 - Spot spray and flame weed non-native species within experimental plots in the fall.
- Pending authorization of the use of prescribed fire, initiate fire treatments.
- 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 plug outplanting.
 - Seed/plant nectar and host plant species into experimental plots depending on the abundance of non-native species after two seasons of treatment.
- Continue to monitor and assess efficacy of management treatments to reduce abundance of non-native species via appropriate weed control measures.
- Remove more trees from between meadows to increase connectivity of meadows for Fender's blue butterfly.
- Begin mowing and non-native species treatment between meadows, in particular between Meadows A and B.
- Maintain Eugene East Recovery Zone Kincaid's lupine seed production beds (0.03 acres).
- Wild-collect native seed from Oak Basin and other mid-elevation sites for starting seed amplification 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.

- Monitor Kincaid's lupine outplanting 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 (wild-collecting seed and growing plugs and/or amplifying seed).

Continued population monitoring will be essential to document population trends for both species, especially in response to restoration activities occurring on 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.

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 community, Kincaid's lupine, and Hitchcock's blue-eyed grass monitoring will enable us to assess the effects and success of ongoing restoration at this site.

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APPENDIX A: SUMMARY OF RESTORATION ACTIVITIES AT OAK BASIN

2012

- Site inspection and partner coordination.

2013

- 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. bifrons* patches.
- Grubbed several *R. bifrons* patches.
- Flame weeded patches for *T. caput-medusae* control and site preparation for planting/seeding.

2014

- 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*, 1.71 lbs *Sidalcea malviflora* ssp. *virgata*.
- Nectar plant availability assessment.
- Hand weeded of *Cirsium vulgare* and *Cytisus scoparius*.
- Mowed 1/3 of all lupine patches and some *R. bifrons* patches.
- Grubbed *R. bifrons*.

2015

- Site inspection and partner coordination.
- Grubbed of *R. bifrons*.
- Removed small diameter conifer 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

- Site inspection and partner coordination.

- Flame weeded medusahead control and site preparation for planting/seeding.
- Grubbed *R. bifrons*.
- Removed small diameter conifer 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

- 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. bifrons*.
- Seeded *Danthonia californica* 2.37 lbs, *Elymus trachycaulis* 2.0 lbs, *Eriophyllum lanatum* 1.28 lbs, *Festuca roemerii* 3.41lbs, *Plectritis congesta* 1.18 lbs, *Prunella vulgaris* var. *lanceolata* 0.75 lbs and *Sidalcea malviflora* ssp. *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

- 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. bifrons*.
- 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. It was 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), *Elymus glaucus* (1.45), *Eriophyllum lanatum* (0.28), *Koeleria micrantha* (0.09), *Plectritis congesta* (0.46), *Prunella vulgaris* (0.38), and *Wyethia angustifolium* (3.27)

2019

- 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. bifrons* 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), *Elymus glaucus* (1.10), *Festuca roemerii* (0.34), and *Wyethia angustifolium* (2.20)

2020

- 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 into flame weeded patches A5 and A6 .
- Cut down approximately 35 conifers along the forest/meadow edge in Meadow C
- Established Eugene East Recovery Zone Kincaid's lupine seed production bed.
- Monitored Kincaid's lupine and Hitchcock's blue-eyed grass

APPENDIX B: KINCAID'S LUPINE COVER AND RACEME COUNTS BY PLOT (2013-2020)

APPENDIX B TABLE 1. KINCAID'S LUPINE (*LUPINUS OREGANUS*) COVER AND RACEME COUNTS BY PLOT FROM 2013-2020. SHADED CELLS INDICATE WHICH PLOTS WERE MOWED IN THE PRECEDING FALL.

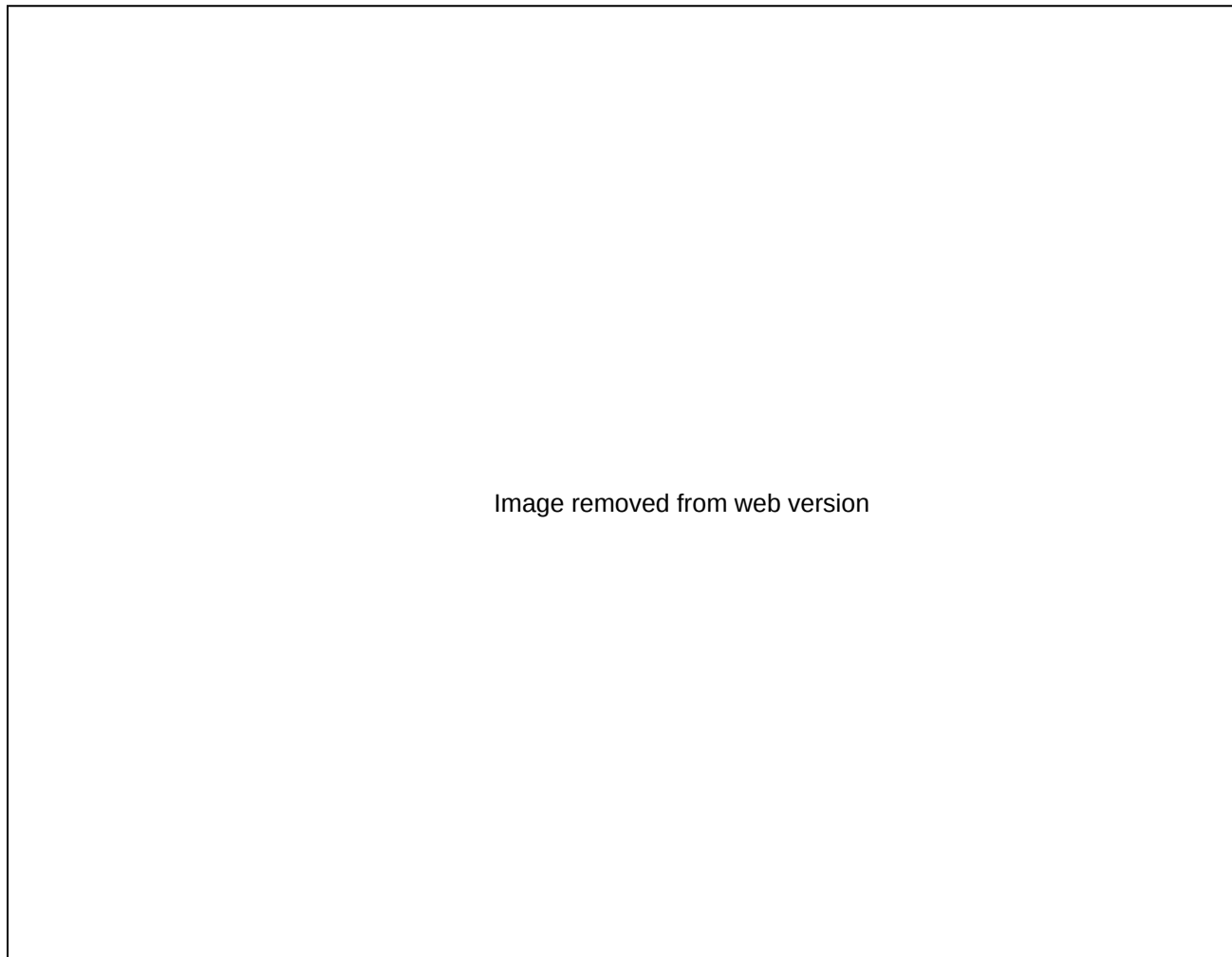
Plot	2013		2014		2015		2016		2017		2018		2019		2020	
	Cover (m ²)	Mature Racemes	Cover (m ²)	Mature Racemes	Cover (m ²)	Mature Racemes	Cover (m ²)	Mature Racemes	Cover (m ²)	Mature Racemes	Cover (m ²)	Mature Racemes	Cover (m ²)	Mature Racemes	Cover (m ²)	Mature Racemes
Meadow A																
TOTAL	42.9	71	80.4	1108	49.2	129	47.3	209	87.5	1996	110.3	1984	103.4	2775	120.8	2320
7	1.1	10	2.9	36	1.8	10	1.9	12	2.8	201	1.8	62	2.1	145	4.1	164
8	0.3	3	0.2	1	0.1	0	0.1	0	0.3	4	0.4	6	0.3	9	0.5	19
9	4.7	2	6.4	146	3.2	24	2.2	5	4.7	49	6.0	30	4.3	25	7.4	162
10	0.4	0	0.8	18	0.4	3	0.6	0	0.5	8	0.6	3	0.5	3	0.8	29
369	-	-	-	-	-	-	-	-	-	-	10.9	50	7.8	0	13.8	8
406	0.7	1	0.3	0	0.0	0	0.1	2	0.3	1	0.4	0	0.5	1	0.4	12
450	10.8	23	11.3	30	7.5	21	3.9	22	6.2	29	7.4	7	15	93	10.5	251
451	0.7	0	1.6	4	0.6	0	0.9	0	1.4	16	1.4	0	0.5	0	0.9	0
452	3.4	6	10.0	93	8.5	9	3.8	0	11.1	129	10.4	34	8.0	25	8.3	116
454	1.8	4	5.7	10	2.6	0	1.3	0	6.8	36	6.4	3	4.7	27	5.7	42
459	9.7	6	19.3	361	11.9	9	16.8	0	26.3	1069	39.3	669	25.1	1142	35.2	555
460	2.4	2	4.8	192	3.0	12	2.5	117	6.5	206	6.4	785	10.1	589	8.7	223
464	5.3	4	13.8	118	6.4	2	7.9	0	17.4	126	12.0	23	14.9	90	9.6	83
509	1.0	8	1.5	52	1.6	30	0.7	51	2.3	56	5.0	239	7.1	462	10.4	550
510	0.3	0	1.4	14	1.3	4	0.0	0	0.1	1	0.8	8	1.6	14	2.2	43
511	0.4	2	0.5	33	0.3	5	4.5	0	0.8	65	1.2	65	1.2	127	1.4	56
Meadow B																
TOTAL	25.5	122	51.6	627	21.4	120	18.9	197	34.7	736	27.9	587	27.4	523	40.3	815
1	8.6	20	31.3	309	11.8	31	8.8	43	23.2	441	12.1	379	13.5	198	16.9	222
2	0.5	1	0.5	1	0.1	1	0.0	0	0.1	3	0.0	1	0.02	0	0	0
3	2.0	5	3.2	21	1.6	7	1.5	13	1.3	15	0.5	5	1.0	16	3.6	49
4	1.7	2	2.5	23	0.7	7	0.9	0	1.5	40	0.4	2	1.1	6	0.7	0
5	4.3	2	6.2	114	4.3	50	1.7	25	1.6	19	4.5	22	3.8	67	5.9	134
6	3.6	51	4.6	125	2.9	24	2.3	21	2.5	51	4.3	107	1.9	36	3.8	80
399	4.9	41	3.3	34	0.0	-	3.7	95	4.6	167	6.1	71	6.1	200	9.4	330
Meadow C																
TOTAL	11.2	44	17.8	311	21.7	177	14.0	217	29.5	881	25.2	471	35.6	1265	31.1	1413

Monitoring and restoration of Kincaid's lupine (*Lupinus oreganus*) and Hitchcock's blue-eyed grass (*Sisyrinchium hitchcockii*) at Oak Basin: 2019 Annual Report

Plot	2013		2014		2015		2016		2017		2018		2019		2020	
	Cover (m ²)	Mature Racemes	Cover (m ²)	Mature Racemes	Cover (m ²)	Mature Racemes	Cover (m ²)	Mature Racemes	Cover (m ²)	Mature Racemes	Cover (m ²)	Mature Racemes	Cover (m ²)	Mature Racemes	Cover (m ²)	Mature Racemes
400	0.1	0	0.1	1	0.04	1	0.04	3	0.05	0	0.1	0	0.1	2	0.4	7
431	1.8	0	2.7	20	3.1	8	1.6	0	3.9	62	2.6	32	4.4	99	0.1	2
432	5.1	42	10.1	173	9.4	86	7.4	187	12.2	408	12.4	322	20.4	741	0.1	7
433	4.2	2	4.8	117	9.1	82	4.3	14	12.3	408	8.7	78	9.1	372	6.1	162
594	-	-	-	-	-	-	0.7	13	0.9	1	1.3	38	1.5	44	16.1	1010
TOTAL	79.6	237	149.8	2046	92.3	426	80.2	623	151.7	3613	163.4	3042	166.4	4540	192.3	4548

APPENDIX C. AERIAL OVERVIEWS

Overview of Meadows A, B and C



APPENDIX C 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 C 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

Image removed from web version

APPENDIX C FIGURE 3. MEADOW A OVERVIEW. PLOTS ESTABLISHED IN 2011 = 509, 510, 511. THE 509 EAST POPULATION IS ON THE SKID ROAD AND EXISTS WITHIN A 1.5M RADIUS OF THE REBAR. THE 510 WEST POPULATION IS ON THE TREE LINE AT 179° FROM LARGE DOUGLAS-FIR (*PSEUDOTSUGA MENZIESII*) AROUND CENTER OF HILL AND EXTENDS IN A 8M X 1M STRIP GOING NORTH-SOUTH. THE 511 CENTER POPULATION IS IN THE MIDDLE OF THE HILL AT 230° FROM THE WESTERNMOST DOUGLAS-FIR OF DOUGLAS-FIR ISLAND ON TOP OF HILL NEAR PLOT 459; CONSISTS OF 5 PLANTS IN A 3M X 0.5M STRIP GOING NORTH-SOUTH.

Meadows B and C overview

Image removed from web version

APPENDIX C 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 NE CORNER AND HAS CONDUIT (OTHER CORNERS HAVE REBAR WITH YELLOW CAPS).

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

APPENDIX D TABLE 2. LOCATION, DIMENSIONS, AND MONITORING NOTES FOR KINCAID'S LUPINE (*LUPINUS OREGANUS*) 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, 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, SE
A	509	Circular, 1.5m radius	504199 E ¹ 4907048N ¹	New in 2011. Measured in 4 quadrats: NW, NE, SW, 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, 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.

Meadow	Plot Number	Dimensions	origin (Nad27)	Notes
B	1	60m x 18m+	504420 E 4906668 N	Measured in 5m increments
B	2	Triangular adjacent to Plot 3	504503 E 4906649 N	Measure 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, 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, 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 on the SW end of Meadow B which is on private property. Plot 399 captures the lupine nearest the public/private boundary.

APPENDIX E. LOCATIONS OF KINCAID'S LUPINE PLANTINGS

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APPENDIX E 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 F. MATURE AND ABORTED RACEMES (2006-2020)

APPENDIX F TABLE 3. TOTAL NUMBER OF MATURE RACEMES AND PERCENT RACEMES ABORTED OF KINCAID'S LUPINE (*LUPINUS OREGANUS*) AT OAK BASIN FROM 2006 TO 2020.

	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	9%	375	13%	145	21%	765	14%
2007	881	9%	1,482	4%	810	5%	3,173	6%
2008	891	9%	1,027	6%	432	9%	2,350	8%
2009	415	18%	1,004	7%	55	42%	1,474	12%
2010	1,860	5%	1,678	4%	108	28%	3,646	5%
2011	1,978	5%	1,845	4%	192	18%	4,015	5%
2012	1,328	7%	969	7%	127	24%	2,424	8%
2013	71	59%	122	39%	44	50%	237	49%
2014	1,108	8%	627	11%	311	12%	2,046	10%
2015	129	47%	120	35%	177	11%	426	32%
2016	209	42%	197	31%	217	20%	623	32%
2017	1,996	8%	736	11%	881	6%	3,613	8%
2018	1,984	8%	587	14%	471	11%	3,042	10%
2019	2,775	31%	523	35%	1,265	16%	4,563	27%
2020	2,320	2%	815	0.9%	1,413	3%	4,548	2%

APPENDIX F TABLE 4. 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 2020.

	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

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

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

APPENDIX H. HABITAT QUALITY SPECIES LISTS

Relevé plots were surveyed on June 30, 2020.

	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 I. 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
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Directions:

To Meadows A, B, and C

South on I-5, take exit 216

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

Turn left onto Northernwood Rd. (5.8 miles from the freeway.) Reset the mileage as you turn onto Northernwood.

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 go right.

At 1.6 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

South on I-5 to Brownsville/Hwy 228 exit 216

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

(Start mileage once turn onto Courtney Creek Road)

Courtney Creek Road becomes Timber Road at ~2.5 miles

Continue past gravel pile (on left) to total of 7.3 miles

Park at (mostly) blocked road, 14-2.34 (signed). Walk in to end of road (approx. 1.5 - 2 miles). Old ATV trail to 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- 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 (marks lupine), pink (marks 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