Maxfield Meadows Meadow and Oak Savannah Restoration

2012

Report to the Bureau of Land Management Salem District

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Institute for Applied Ecology

PREFACE

This report is the result of a cooperative Challenge Cost Share project between the Institute for Applied Ecology (IAE) and a federal agency. IAE is a non-profit organization whose mission is conservation of native ecosystems through restoration, research and education. IAE provides services to public and private agencies and individuals through development and communication of information on ecosystems, species, and effective management strategies. Restoration of habitats, with a concentration on rare and invasive species, is a primary focus. IAE conducts its work through partnerships with a diverse group of agencies, organizations and the private sector. IAE aims to link its community with native habitats through education and outreach.

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Cover photograph:

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EXECUTIVE SUMMARY

Maxfield Meadows is a 370 acre parcel composed of Douglas-fir (*Pseudotsuga menziesii*) forest, Oregon white oak (*Quercus garryana*) woodland, and meadows managed by the Salem District BLM. Restoration of this site was initiated in 2007. Restoration goals include improving oak woodland and savannah habitat and controlling invasive species (primarily false-brome, *Brachypodium sylvatium*). The Institute for Applied Ecology began working with the BLM to initiate restoration actions in 2008.

- **Vegetation sampling in meadows**. In 2008, we monitored vegetation transects originally sampled in 2004. We found that all meadows were heavily invaded, with higher cover and richness of invasive species relative to natives. However, sampling of areas that had been seeded after burning piled debris from thinning found that these areas were dominated by native species, suggesting that intense prescribed fire may be an effective restoration treatment in these meadows.
- **Kincaid's lupine (*Lupinus oreganus*) introduction.** Although it is unknown if *L. oreganus* was ever present at Maxfield Meadows, the nearest extant population is less than 1 mile away from Pit Road Meadow. In 2008, 1000 seeds were sown at Pit Road Meadow. This effort resulted in 11 individuals in 2010, suggesting that the habitat may be suitable for *L. oreganus*. However, this site is heavily invaded by exotic grasses and forbs and further introductions should be initiated only after restoration of this meadow.
- **False-brome (*Brachypodium sylvaticum*) control**. Several patches of false-brome have been observed in the 10-5-19 parcel and forest adjacent to Pit Road Meadow. These patches varied in size from 2-3 individuals to a large patch extending along a creek. Since 2008, we have been treating these patches using manual and chemical methods.
- **Xeric meadow restoration**. In 2009, we initiated a small experiment to test several meadow restoration methods to inform restoration when funds become available to treat these areas. We found that burning plus seeding was the most effect treatment in terms of decreasing litter and increasing native cover, although native diversity did not increase and exotic cover remained high. We did not see a response from carbon addition, litter removal (raking), or only seeding.
- **Oak savannah restoration**. Restoration of the oak savannah, including selective timber harvest, brush clearing, a broadcast burn, and heavy seeding, is currently scheduled to begin in 2013. Activities that may be implemented by IAE include controlling invasive species, seeding, planting of oak seedlings, and treating soils to facilitate establishment of native species. Some of these activities may be implemented by IAE in 2014. Specific activities will be determined through consultation with BLM staff and dependent on site conditions post-timber harvest in September 2013.
- **In 2013, timber harvest began.** The total harvest is expected to be 268 acres of the site.

In 2011 and 2012, activities were restricted to *Brachypodium* control

Maxfield Meadows Meadow and Oak Savannah Restoration

REPORT TO THE BUREAU OF LAND MANAGEMENT, MEDFORD DISTRICT

INTRODUCTION

Project Overview

In several province-wide habitat assessments, Oregon white oak (*Quercus garryana*) savanna and woodlands have been identified as high priority areas for wildlife habitat conservation in the region. Through inventory, the Salem District BLM (BLM) has identified a relatively large area of restoration (370 ac.) of these native habitats, known as the Maxfield Creek Project. The Nature Conservancy has also identified the area as an ecologically important site and nominated it for status as an ACEC (Area of Critical Environmental Concern) in the BLM planning process. Planning documents for the restoration project were completed (Maxfield Creek Density Management/Woodland Restoration/Upland Restoration Environmental Assessment No. OR080-04-19, January 2007), and restoration work began in 2007. Key actions needed to restore the desired habitat conditions in the project area include monitoring, control of invasive species, prescribed burning, seeding and planting of native species, and potential re-introduction of endangered species in areas of suitable habitat.

The objectives of this project are to:

1) **Cooperate in site-level, 3-5 year restoration planning**. Baseline vegetation data and stand data was collected in 2004, and broad project-level planning, including all sites, has been completed. Planning may include assessing information needs, assessing current habitat conditions, refining restoration goals, and developing strategies and actions for site-level restoration.
2) **Collect and analyze data to meet mutually agreed information needs**. Data collection could include: additional baseline vegetation composition and condition data (revisit/augment 2004 transects), monitoring vegetation effects from 2007 restoration actions, inventorying potential sites for re-introduction of endangered plant species, inventorying populations of invasive species.
3) **Plan and implement control of invasive species.** The initial objective was control of up to approximately 8 known sites of false-brome (*Brachypodium sylvaticum*) totaling 0.5-1.0 acre. Since the original planning stage, we have identified and treated several more patches. We will continue to treat all false-brome patches as they are located.
4) **Cooperate in native species seeding and planting.**

This report summarizes the work completed to meet these objectives in 2008– 2012.

RE-SAMPLING OF 2004 BOTANY SURVEY TRANSECTS

Introduction

In 2004, Salix Associates conducted botanical surveys of the meadows in the Maxfield Meadows project area (Salix Associates 2004). Two transects were established in each meadow, one in open meadow and one in the transition zone (edge) from open meadow to conifer forest. In late June of 2008, we re-surveyed transects located in Pit Road, West, Middle, and East meadows (Table 1).

Methods

Two transects were established in each meadow. Each transect was 1m x 10m and oriented on a cardinal compass bearing. Tall, white fiberglass poles originally marked the origin and centerline of each plot. Several of these poles were missing in 2008 and plot origins were established based on their bearing and distance from a monument tree. Monument trees were greater than 9 inches dbh and marked with a metal shiner tag. The tags were inscribed with the meadow ID, date, surveyor's initials, transect number, transect bearing and distance and bearing to the transect from the reference point.

In 2004 the 1m x 10m plot was split in to two 0.5m x 10m subplots (north and south or east and west). In 2008, we created ten 1mx1m subplots to make cover estimates more consistent and reliable. Within each subplot, we estimated the cover of each plant species and average height of several randomly selected individuals of each species (Figure 1). Percent cover was averaged for the two transects in each plot. In our data summaries, we excluded cover of *Oregon white oak* if it was in the upper canopy. This only affected one transect in Pit Road.

FIGURE 1. 2008 RE-SURVEY OF A 2004 SALIX ASSOCIATES TRANSECT.

Table 1. Locations of 2008 botany survey transects. UTM readings (NAD 27, CONUS 10T) were taken at the 0m point on each transect. Transect bearing is the direction from the 0m to 10m points. Species abbreviates are, ACMA = *Acer macrophyllum*, QUGA = *Quercus garryana*, PSME = *Pseudotsuga menziesii*. DBH was recorded in 2004.

Site and transect	TRS	Easting	Northing	Transect bearing	Species	DBH (in)	Distance	Bearing
Pit Road Meadow								
1	T10S R06W Sec. 22 SE of NE	468388	4948367	180	ACMA	16.1	14.02	190
2		468406	4948400	90	QUGA	28.4	11.28	255
10-5-19 West Meadow								
1	T10S R05W Sec. 19 NW of NW	471944	4948635	270	PSME	63.0	43.20	163
2		471969	4948633	90	QUGA	9.5	14.17	238
10-5-19 Middle Meadow								
1	T10S R05W Sec. 19 NW of NW, NE of NW	472286	4948741	270	PSME	32.4	24.57	240
2		472295	4948747	270	PSME	32.4	11.43	287
10-5-19 East Meadow								
1	T10S R05W Sec. 19 NE of NW, NW of NE	472560	4948687	180	PSME	60	10.70	123
2		472526	4948699	180	PSME	60	16.94	223

Results

Pit Road Meadow. In 2004, Salix Associates found that the Pit Road meadow had the lowest native plant diversity and abundance of all the meadows they surveyed (Table 2; Appendix A). At the time, the meadow was dominated by *Arrhenatherum elatius* (exotic graminoid), *Fragaria virginiana* (native forb) and *Leucanthemum vulgare* (exotic forb). Several woody species, including *Pseudotsuga menziesii*, *Toxicodendron diversilobum*, and *Amelanchier alnifolia* var. *semiintegrifolia*, were encroaching.

Similarly, we found that both the native plant cover and richness were relatively low at Pit Road Meadow. Cover continued to be dominated by *Leucanthemum vulgare*, *Arrhenatherum elatius*, and *Fragaria virginiana*. The exotic grasses *Dactylis glomerata* and *Schedonorus phoenix* (*Festuca arundinaceae*) also had relatively high cover.

10-5-19 West Meadow. In 2004, Salix Associates found that this dry meadow was dominated by the exotic grasses *Arrhenatherum elatius*, *Taeniatherum caput-medusae*, *Bromus rigidus* (*Bromus diandrus*), *Cynosurus echinatus*, *Bromus hordeaceus*, *Bromus sterilis*, *Cynosurus echinatus* and the native grass, *Elymus glaucus* (Appendix A). In 2008, the cover in West Meadow transects was dominated by the exotic forb *Crepis capillaris* and exotic grasses *Bromus diandrus, Bromus hordeaceus*, *Cynosurus echinatus*, and *Vulpia bromoides*. In both 2004 and 2008, native perennial bunchgrasses, including *Achnatherum (Stipa) lemmonii*, *Bromus sitchensis*, and *Danthonia californica* were present but very uncommon. Over-all cover at this site was low, 59.7%, with only 8.8% of that from native species (Table 3). However, species richness in this meadow was relatively high, with 19 native and 16 exotic species found along the transects.

Table 2. Species cover and Richness at Pit Road Meadow, 2008.

	Cover		
	Exotic	Native	Total
Graminoids	35.1	2.3	37.3
Forbs	16.3	22.0	38.3
Trees/Shrubs	6.4	12.8	19.2
Total	***57.8***	***37.1***	***94.9***
	Richness		
	Exotic	Native	Total
Graminoids	9.0	3.0	12.0
Forbs	9.0	8.0	17.0
Trees/Shrubs	1.0	4.0	5.0
Total	***19.0***	***15.0***	***34.0***

Table 3. Species cover and Richness at West Meadow, 2008.

	Cover		
	Exotic	Native	Total
Graminoids	38.5	2.1	40.6
Forbs	12.4	6.7	19.1
Trees/Shrubs	0.0	0.0	0.0
Total	50.9	8.8	59.7
	Richness		
	Exotic	Native	Total
Graminoids	8.0	5.0	13.0
Forbs	8.0	14.0	22.0
Trees/Shrubs	0.0	0.0	0.0
Total	16.0	19.0	35.0

10-5-19 Middle Meadow. Like the West Meadow, Middle Meadow was dominated in both 2004 and 2008 by weedy forbs and grasses including *Crepis capillaris*, *Cynosurus echinatus*, *Taeniatherum caput-medusae*, *Vulpia bromoides*, *Arrhenatherum elatius*, and *Bromus diandrus* (Table 4, Appendix A). The most abundant native species included *Daucus pusillus*, *Madia gracilis*, *Lotus micranthus*, and *Bromus sitchensis*.

Table 4. Species cover and Richness at Middle Meadow, 2008.

	Cover		
	Exotic	Native	Total
Graminoids	26.6	6.4	33.1
Forbs	5.8	18.7	24.5
Trees/Shrubs	0.0	0.0	0.0
Total	32.4	25.1	57.5
	Richness		
	Exotic	Native	Total
Graminoids	6.0	3.0	9.0
Forbs	6.0	8.0	14.0
Trees/Shrubs	0.0	0.0	0.0
Total	12.0	11.0	23.0

10-5-19 East Meadow. Compared to the West and Middle Meadows, East Meadow had the highest number and cover of native species (Appendix A). However, this meadow was still dominated by exotic species, particularly, *Cynosurus echinatus*, *Bromus hordeaceus*, *Crepis capillaris*, *Leucanthemum vulgare*, and *Torilis arvensis* (Table 5). The

most abundant native forbs and grasses were *Lonicera hispidula*, *Madia gracilis*, *Bromus sitchensis,* and

Danthonia californica. Similar results were found in 2004. The native shrub, *Toxicodendron diversilobum*, was also relatively abundant on the transects.

Table 5. Species cover and Richness at 10-5-19 East Meadow.

	Cover		
	Exotic	Native	Total
Graminoids	22.4	9.1	31.6
Forbs	25.1	12.2	37.4
Trees/Shrubs	3.7	13.2	16.8
Total	51.2	34.5	85.7
	Richness		
	Exotic	Native	Total
Graminoids	10.0	4.0	14.0
Forbs	10.0	18.0	28.0
Trees/Shrubs	1.0	2.0	3.0
Total	21.0	24.0	45.0

EFFECTIVENESS OF 2007 RESTORATION SEEDING

Introduction

In 2007, several burn piles were created in the 10-5-19 meadows after restoration work. These piles were seeded with native species and planted with *Brodiaea coronaria* and *Wyethia angustifolia*. In 2008, we surveyed these burn piles to determine the effectiveness of these restoration efforts.

Methods

In May – June 2008, we visited each burn pile in the East and West Meadows to assess the effectiveness of seeding and planting plugs. For each burn pile, we documented the location and determined the cover of each species. Cover was estimated as a percent of the entire burn pile (Appendix B). In order to make general conclusions, we averaged the cover of all burn piles within each meadow.

FIGURE 2. GERMINATION ON SEEDED BURN PILES WAS RELATIVELY HIGH (JUNE 2008) *(PHOTO: B. MARTIN)*

Results and Discussion

On average, the total cover of plants on burn piles in the East Meadow was 91%, with near equal cover of forbs and grasses (Figure 2, Figure 3). Exotic species, including *Cirsium vulgare*, *Sherardia arvensis*, *Vicia sativa*, *Cynosurus echinatus*, and *Lolium perenne* covered an average of 1.2% of each burn pile. The most abundant native species were the forbs *Achillea millefolium*, *Clarkia purpurea*, *Collinsia grandiflora*, and *Madia gracilis;* and grasses *Bromus sitchensis, Elymus glaucus*, and *Festuca roemeri*

In the West Meadow, the average total cover on the burn piles was 86.6%. No exotic species were found. The most abundant species included the forbs *Achillea millefolium*, *Clarkia purpurea*, *Collinsia grandiflora*, and *Collomia grandiflora;* and grasses *Bromus sitchensis*, *Elymus glaucus*, and *Festuca roemeri*.

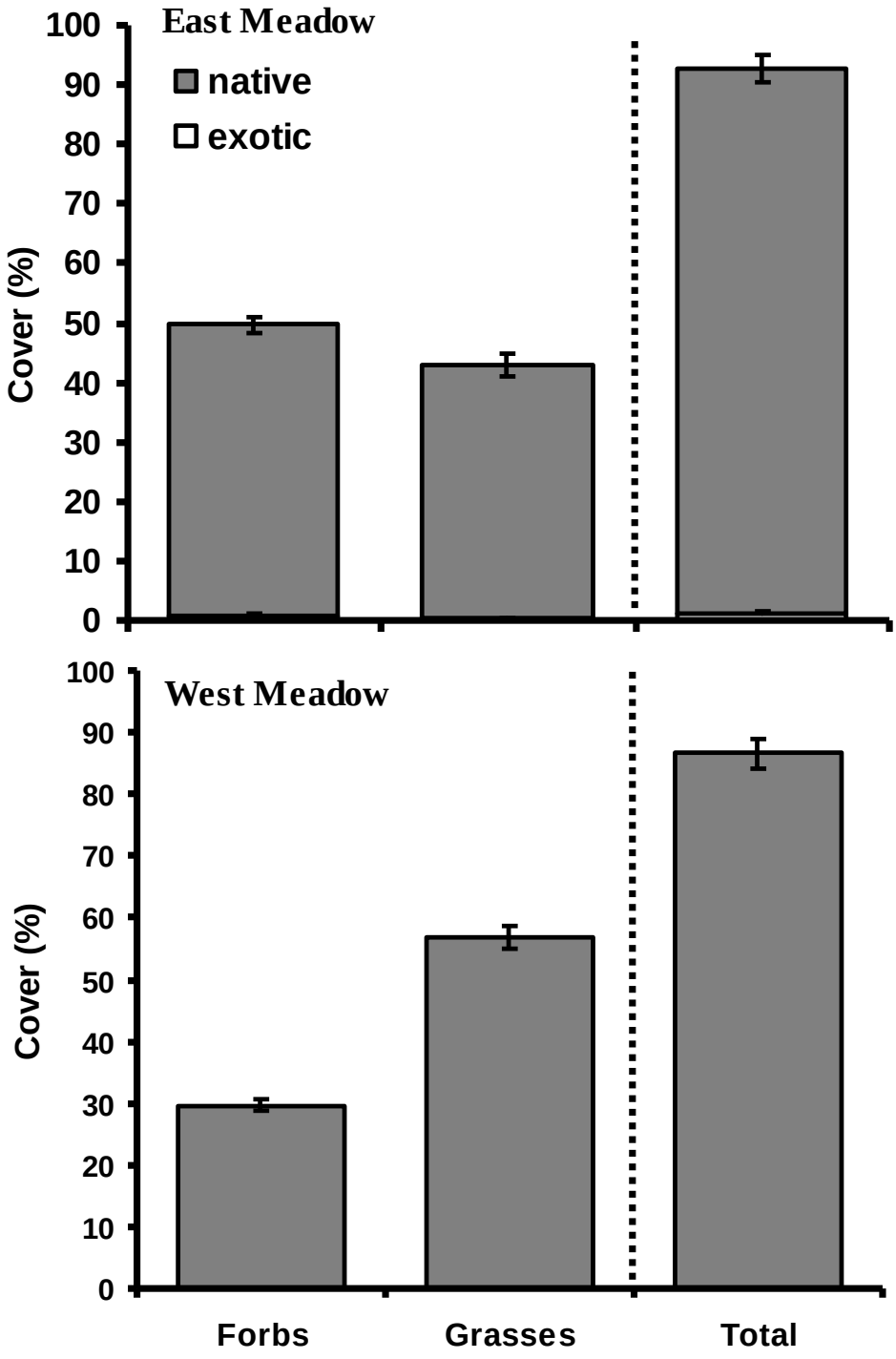

FIGURE 3. COVER OF NATIVE AND EXOTIC FORBS AND GRASSES ON BURN PILES IN EAST AND WEST MEADOWS.

Three native species were identified on the burn piles that were not on the list of species included in the seed mixes: *Lotus micranthus*, *Pteridium aquilinum*, and *Trifolium* cf. *willdenovii*. If these species were not in the seed mixes, their ability to colonize the burn piles suggests that they may be good species to use in future restoration efforts.

The relatively high cover of native species and low invasion suggests that restoration seeding can be quite successful. If these burn piles are maintained relatively free of exotics and the natives continue to thrive, it is possible that they can serve as seed sources for the surrounding, unseeded meadow.

Future activities

In 2010, we observed very little establishment of invasive species on burn piles. As time permits, we will continue to visit these areas to document establishment of native and invasive species and control invasives as necessary. In 2011 and 2012, activities were restricted to *Brachypodium* control and these burn piles were not revisited.

LUPINUS OREGANUS (KINCAID'S LUPINE) REINTRODUCTION

Introduction

Kincaid's lupine (*Lupinus oreganus*); Figure 4), a rare member of the legume family (Fabaceae), is listed by the Oregon Department of Agriculture and the U.S. Fish and Wildlife Service as a threatened species. This species is found in native prairie remnants in the Willamette Valley and southwestern Washington, and forest openings in Douglas County, Oregon. In the Willamette Valley, *L. oreganus* serves as the primary larval host plant for the endangered Fender's blue butterfly (*Icaricia icaroides fenderi*), making conservation of the *L. oreganus* a common strategy for recovery of both species.

FIGURE 4. KINCAID'S LUPINE *(PHOTO: A. THORPE)*.

Only 57 sites are known to support *L. oreganus* and fewer than 20 of these are larger than 1 hectare (Wilson et al. 2003). Additionally, the majority of the sites are on privately held land, which is exempt from protections provided by state and federal listing, increasing the importance of management by state and federal agencies on public land.

Although it is unknown if *L. oreganus* was ever present at Maxfield Meadows, it is known to have historically occurred in the vicinity. The nearest extant population is less than 1 mile away from Pit Road Meadow on the edge of sections 15 and 22 (Figure 5).

In 2008, the US Fish and Wildlife Service released the Draft Recovery Plan for Willamette Valley Prairie Species (USFWS 2010). Establishing a population of *L. oreganus* at Maxfield Meadows would contribute to the recovery objectives for the plan. Although there are some patches of potential habitat in the Upper Meadows in section 19, these patches are fairly small, distant from other *L. oreganus* populations, and separated from other populations by mixed-coniferous forest. These factors would potentially limit genetic exchange between introduced plants and unrelated plants, ultimately limiting success of the restoration. In addition, it is unlikely that Fender's blue butterfly would colonize the site. Instead, we focused our efforts in 2008 on determining the potential of the Pit Road Meadow to host a population of *L. oreganus*. Although this meadow is relatively weedy, it is the largest mesic meadow at Maxfield Meadows and contains several species that are often associated with *L. oreganus* (including *Achillea millefolium*, *Fragaria virginiana*, and *Viccia* ssp.)

Methods

Seeding occurred on 10 December, 2008. Two 19m transects were established in the Pit Road Meadow (Figure 6, Figure 7). Transects were placed so that they would not intersect large patches of *Rubus armeniacus*, *Dipsacus fullonum*, and *Cirsium vulgare*. Ten $1m^2$ plots were established on each transect, leaving a 1m buffer between each plot. Plot corners were marked with PVC-conduit, then were raked to remove competing vegetation and thatch (Figure 8). Fifty scarified lupine seeds were distributed in each plot, for a total of 500 seeds per transect, and 1000 seeds at the site. Students from King's Valley Charter School assisted with plot establishment and seeding.

In April 2009, we visited all plots, surveyed for seedlings, and removed all competing vegetation in plots where plants were present. In May 2009 and June 2010 we counted the number of *L. oreganus* seedlings and monitored their size by counting leaf number and measuring foliar cover.

Results

Sixteen *L. oreganus* seedlings were counted in May 2009, representing a 1.6% establishment rate. Survivorship of these 16 plants from 2009 to 2010 was high, with 11 plants found in June 2010 (68% survivorship). Thus after 2 years, 1.1% of the seed sown germinated and survived. None of the plants flowered in 2009 or 2010. Surviving plants were larger in 2010, with an average of 6.3 leaves per plant in 2010 compared to 3.8 leaves/plant in 2009.

Future activities and restoration recommendations

Our results suggest *L. oreganus* could be successfully introduced to Pit Road meadow. We recommend site restoration including significant reduction of invasive species and increase in native species diversity and cover before large-scale introductions of this species.

The restoration concerns at Pit Road include high cover of both invasive forbs and grasses, colonization of the meadow by shrubs and tree seedlings, and a thick layer of thatch and litter. In order to address these issues, we recommend a fall controlled burn followed by spot spraying of germinating species approximately one to two weeks post-burn. The majority of species that germinate immediately after fall burns are invasive species and experiments in upland prairies throughout the Willamette Valley and Puget Trough have demonstrated that this combination of treatments leads to higher restoration success (Boyer 2008, Stanley et al. 2008). We recommend that these treatments be followed by heavy seeding of native species and continued spot treatments for invasives. As many of the invasive species at this site are in the Asteraceae family, aminopyralid may provide high levels of control while having fewer effects on non-target plant species.

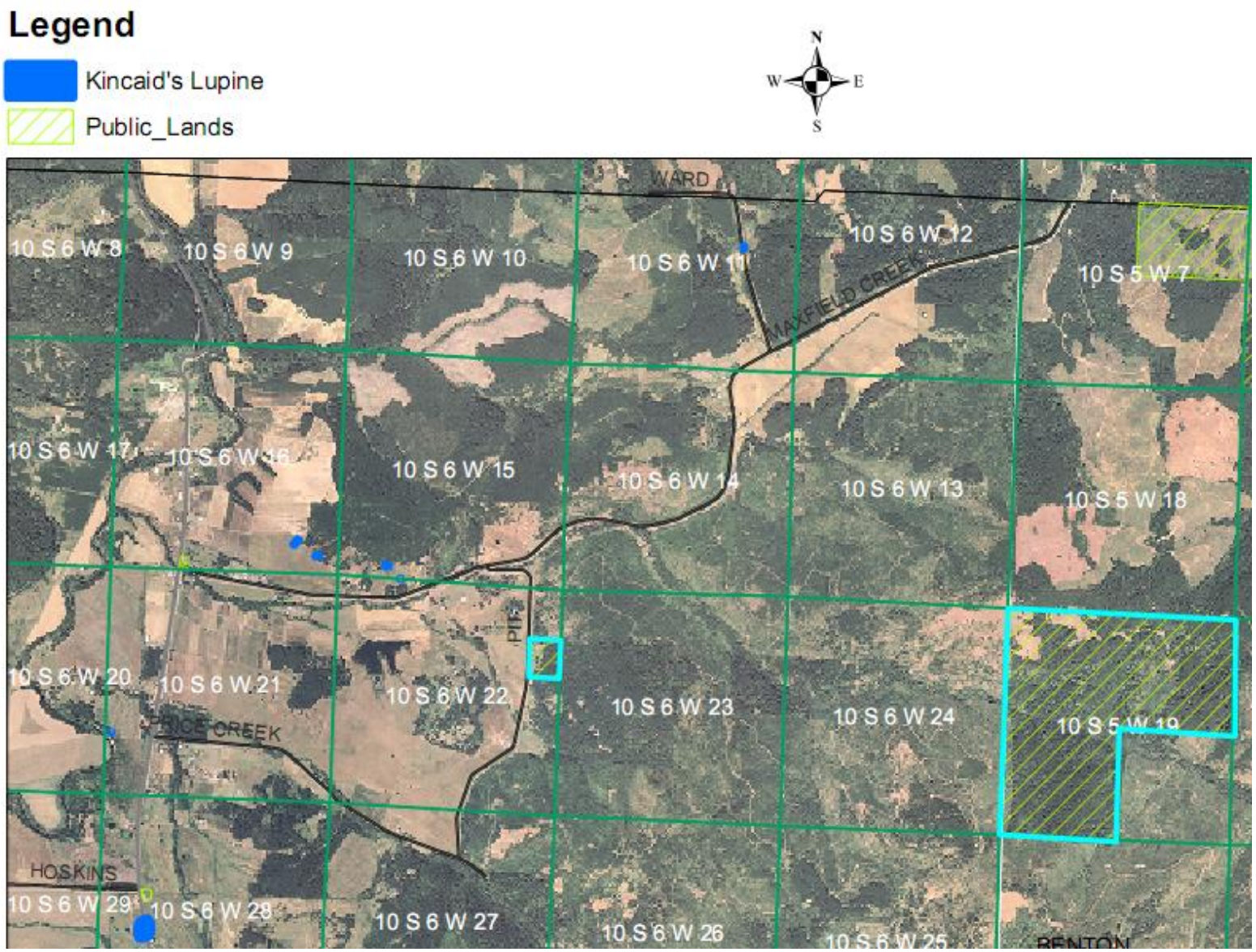

FIGURE 5. THE LOCATION OF KINCAID'S LUPINE POPULATIONS IN THE VICINITY OF MAXFIELD MEADOWS.

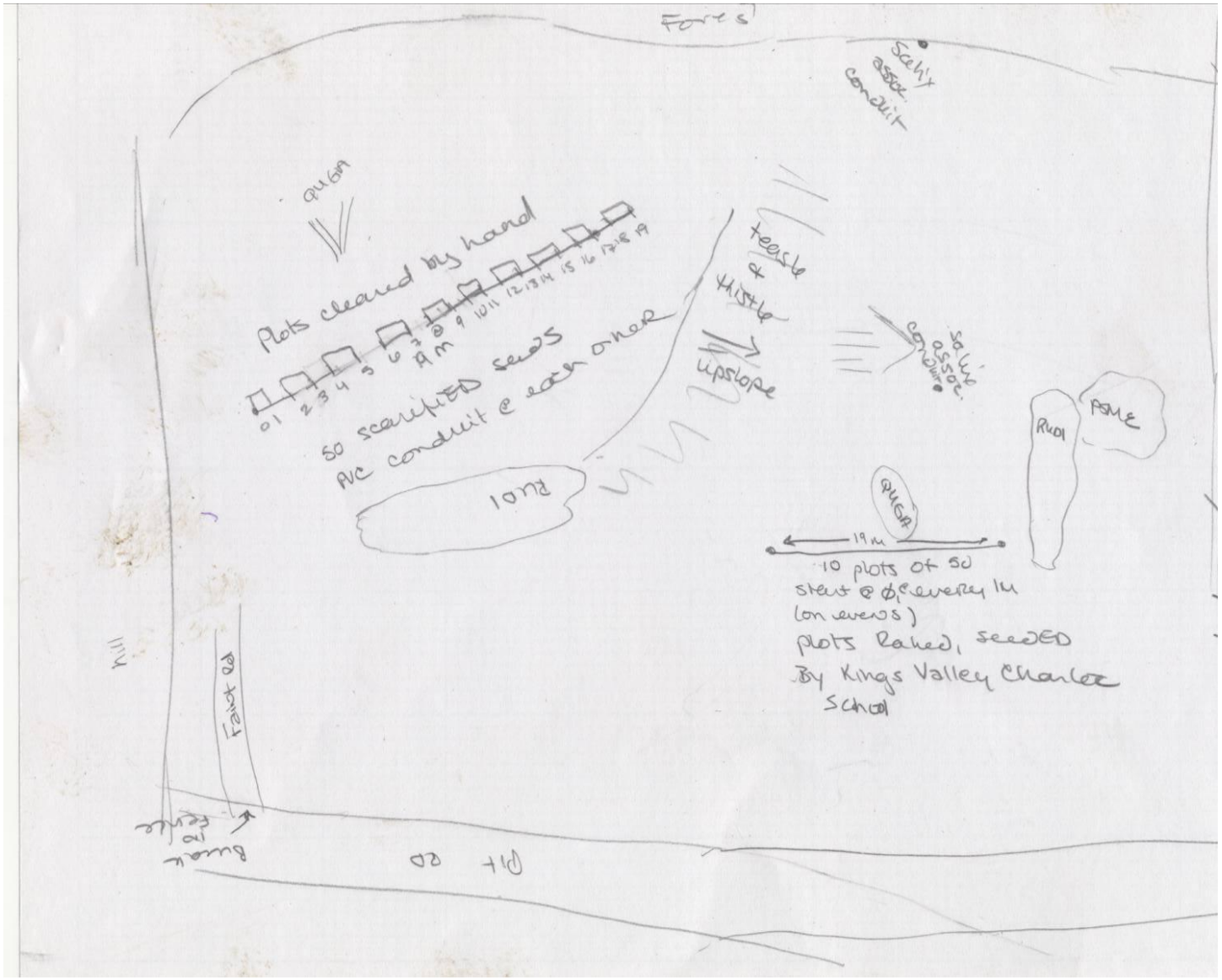

FIGURE 6. *LUPINUS OREGANUS* (KINCAID'S LUPINE) SEEDING PLOTS AT PIT ROAD MEADOW. MAP NOT TO SCALE.

FIGURE 7. *LUPINUS OREGANUS* (KINCAID'S LUPINE) INTRODUCTION PLOTS AT PIT ROAD MEADOW (10 DECEMBER, 2008).

FIGURE 8. *LUPINUS OREGNAUS* (KINCAID'S LUPINE) INTRODUCTION PLOTS AT PIT ROAD MEADOW, 10 DECEMBER 2008. ABOVE: STUDENTS FROM KING'S VALLEY CHARTER SCHOOL RAKING PLOTS. BELOW: PREPARED PLOTS WITH PVC-CONDUIT MARKING EACH COVER OF THE 1M^2 PLOT.

BRACHYPODIUM SYLVATICUM CONTROL

Introduction

Brachypodium sylvaticum (Huds.) Beauv (False-brome; Poaceae) is an invasive perennial grass which is quickly spreading through the Pacific Northwest. It is listed by the Oregon Department of Agriculture as an invasive species (B List). New populations of the grass have recently been reported from San Mateo County, California to Beacon Rock State Park, Skamania County, Washington. The grass is designated as an A list species in California and is proposed as a Class A noxious weed for 2009 by the Washington State Noxious Weed Control Board. The earliest record of the species in North America is a 1939 collection from near Eugene in Lane County, Oregon. By 1966 the species grew in at least two large colonies in the Corvallis-Albany area of Benton County, Oregon, where it was apparently thoroughly naturalized (Chambers 1966). It is capable of completely dominating understory and open habitats to the exclusion of most other native species and its palatability to wildlife is very low. It appears to inhibit tree seedling establishment and may displace endangered species, such as *Lupinus oreganus*, Fender's blue butterfly, and the threatened roadside plant, wayside aster (*Eucephalus vialis* (Bradshaw)).

Brachypodium sylvaticum has an exceptionally broad ecological amplitude, occupying forest floor and open environments at elevations between 200 and 3,500 feet. Populations are known from riparian forests as well as upland hardwood and conifer forests under closed canopy. Vigorous populations also occupy forest edges and upland prairies in full sun. When invading an area, it may first disperse along roadsides or forest edges, then move out into undisturbed areas, meadows, and clear cuts.

In the Willamette Valley, this species may occur with native perennial grasses such as *Bromus vulgaris* (Hook.) Shear, *Festuca subulata* Trin., and *Melica subulata* (Griseb.) Scrib. in forest understories, and *Elymus glaucus* Buckl., *Bromus carinatus* Hook. & Arn., *Danthonia californica* Boland., and *Festuca californica* Vasey, in open areas such as upland prairies and along forest edges. Other species that may be confused with *Brachypodium sylvaticum* include *Hierochloe odorata* (L.) Beauv., *Bromus vulgaris* (Hook.) Shear and *Holcus lanatus* (L.).

Several patches of *Brachypodium* had been observed in the 10-5-19 parcel and near Pit Road Meadow. These patches varied in size from 2-3 individuals to a large patches roughly 45-100m^2. Our objective is to remove all *Brachypodium* using both manual and chemical methods.

Control efforts

Between May and July 2008, before the plants had gone to seed, six patches of *Brachypodium* were located and either hand pulled or spayed with herbicide (Table 5, Figure 9). On 30 May, 2008, approximately 0.84 lbs glyphosate was applied using a hand sprayer to patches 2 and 4. On 13 March, 2009, we surveyed for *Brachypodium*, focusing on the areas that were treated in 2008. Several live patches were found and hand pulled. We removed a total of six large trash bags of plants.

In September 2009, approximately 12 pounds of native seed was distributed over the approximately 100m^2 that had been treated for *Brachypodium*. The seed was a custom mix of the Heritage Seedlings edge mix that was composed of seeds collected from Maxfield Meadows and additional species added due to their vigorous growth (*Ligusticum apiifloium* and *Prunella vulgaris* var. *lanceolata*) or potential to fill

a similar niche as *Brachypodium* (*Aquilegia formosa* and *Bromus vulgaris*) (Appendix C). Seed was mixed with vermiculite (50/50 by volume) to facilitate application.

Table 6. Size, description, and treatment of *Brachypodium* control areas. Areas correspond to patches marked on Figure 9 and Figure 10.

Name	Size	Description	Treatment
A	5x5m	Future monitoring needed to determine identity of unknown seedlings	5/27/09: Pulled 3/15/10: No plants located
B	~500 m^2	Large patch, in two openings in the forest, as well as down along the stream. Adult plants still being located, but population substantially smaller. Site needs long-term monitoring to eradicate stragglers and seedlings.	5/30/08: Sprayed 6/24/08: Pulled ~4 bags 3/13/09: Pulled ~8 bags 5/27/09: Pulled ~1 bag 6/8/09: Pulled ~3 bags 3/15/10: Pulled ~1.5 bags *Area should be checked in spring 2013*
C	1-2 m^2	dense patch 1-2 m^2, 10-20 plants within 20 m of the area	6/24/08: Pulled ~1/2 bag 6/8/09: Pulled ~1/2 bag 3/15/10: No plants located 6/19/12: Pulled scattered individuals
D	Circular patch 1 m^2	Drainage takes a turn E/W at break in slope	6/24/08: Pulled ~1/4 bag 5/27/09: Pulled, scattered plants 6/8/09: Pulled, scattered plants 3/15/10: No plants located
E	Circular patch 1 m^2		5/30/08: Sprayed 5/27/09: Pulled ~1/4 bag 6/8/09: Pulled ~ a few plants 3/15/10: No plants located

Size, description, and treatment of *Brachypodium* control areas. Areas correspond to patches marked on Figure 9 and Figure 10.

Name	Size	Description	Treatment
F			3/19/10: No plants located
G	200-300 m^2	Large population above road, along skid road, and stream. Patchy to continuous Population will need long-term monitoring after eradication of adults to control seedlings. Population also continues below road along stream and as scattered individuals on terrace above Maxfield Creek.	3/18/10: Pulled 10 bags from area nearest G. 3/29/10: Pulled 20-25 ft^3 of plants above and below G. 04/8/10: Pulled ~10 bags along creek above road and in stream terrace below road. 6/21/12: Pulled 12 bags from above the road, up the stream and in the skid road. Pulled 3 bags below the road.
H	0 plants	Western Meadow	6/8/09: Confirmed, no BRSY present
I	6 Hand pulled, scattered plants within 10m	Plants are below a fallen tree at the base of a clearing. A steep drainage is just to the East.	6/8/09: Pulled ~1.5 bags 3/19/10: No plants located
J	Few individuals		5/27/09: Pulled 3/15/10: No plants located
K	2-3 individuals		6/24/08: Pulled 3/19/10: No plants located, GPS point in area where several large trees have been felled.
NEW	~15 m^2	Patch discovered (3/19/10) between patches L & K, consists of large patch (~10 m^2) and scattered individuals	04/8/11: Plants sprayed with glyphosate. *Area will be checked in 2013.*
L	10 m^2		6/24/08: Pulled ~ 3 bags 3/19/10: No plants located

Size, description, and treatment of *Brachypodium* control areas. Areas correspond to patches marked on Figure 9 and Figure 10.

Name	Size	Description	Treatment
M	2-3 individuals		6/24/08: Pulled 3/19/10: No plants located
N	2-3 individuals		6/24/08: Pulled 3/19/10: No plants located
O	5 m^2, scattered plants		6/24/08: Pulled ~1.5 bags 3/15/10: Same as B?
007	20 m^2	Triangular patch found fall 2010.	4/8/11: Sprayed with glyphosate. *Area will be checked in 2013.*
Pit Road		On North and West edges of property; 1: 6 m^2; 2: 6 m^2; 3: 30 m^2; 4: 5 m^2; 5: 100 m^2; 6: 1 m^2; 7: 1 m^2	4/8/11: Patches sprayed with glyphosate. *Area will be checked in 2013*

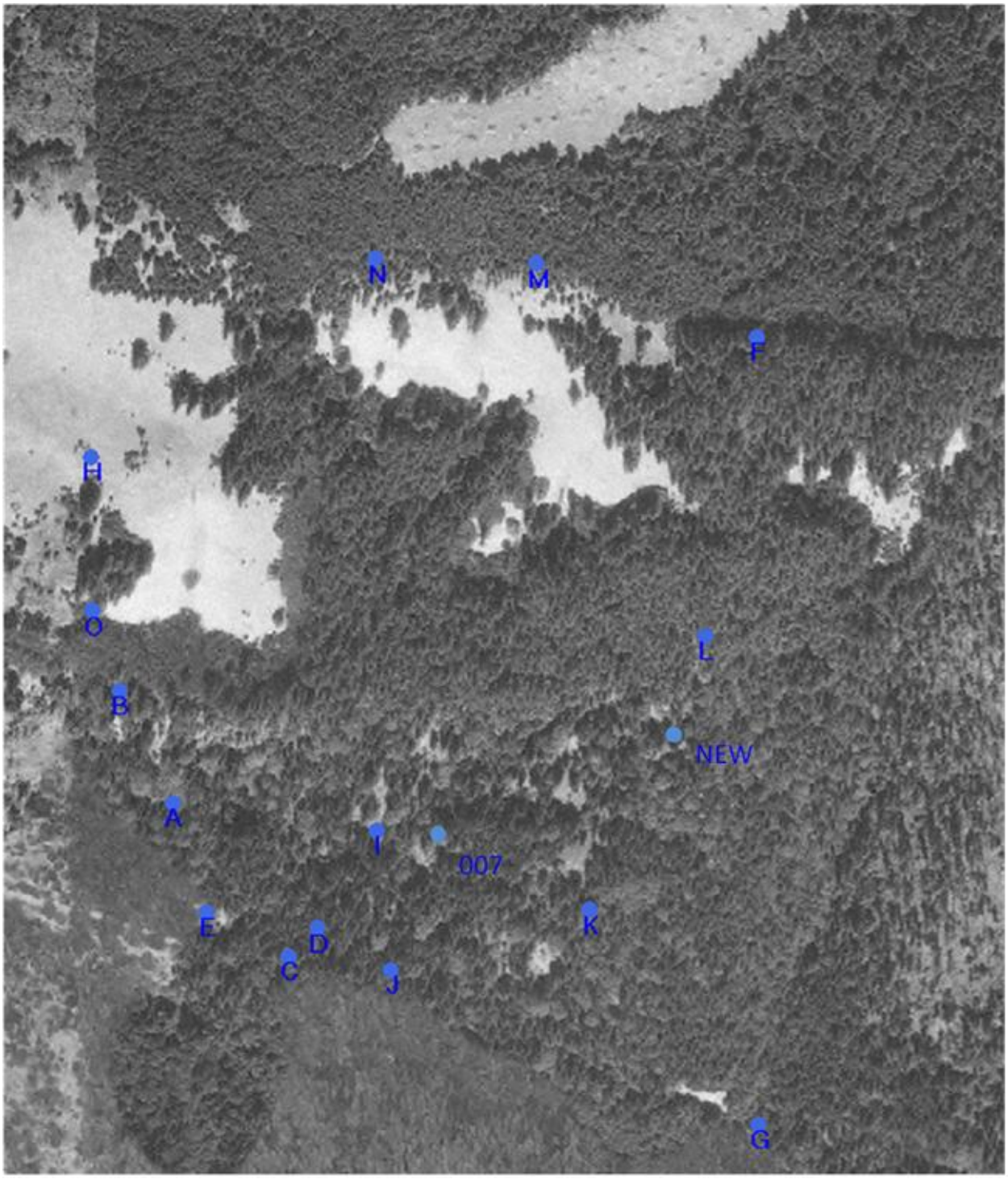

FIGURE 9. AERIAL PHOTO OF *BRACHYPODIUM SYLVATICUM* CONTROL AREAS AT MAXFIELD MEADOWS. LETTERS REFER TO PATCHES DESCRIBED IN TABLE 5. CIRCLES REPRESENT POINTS IN THE CENTER OF EACH PATCH AND ARE NOT TO SCALE.

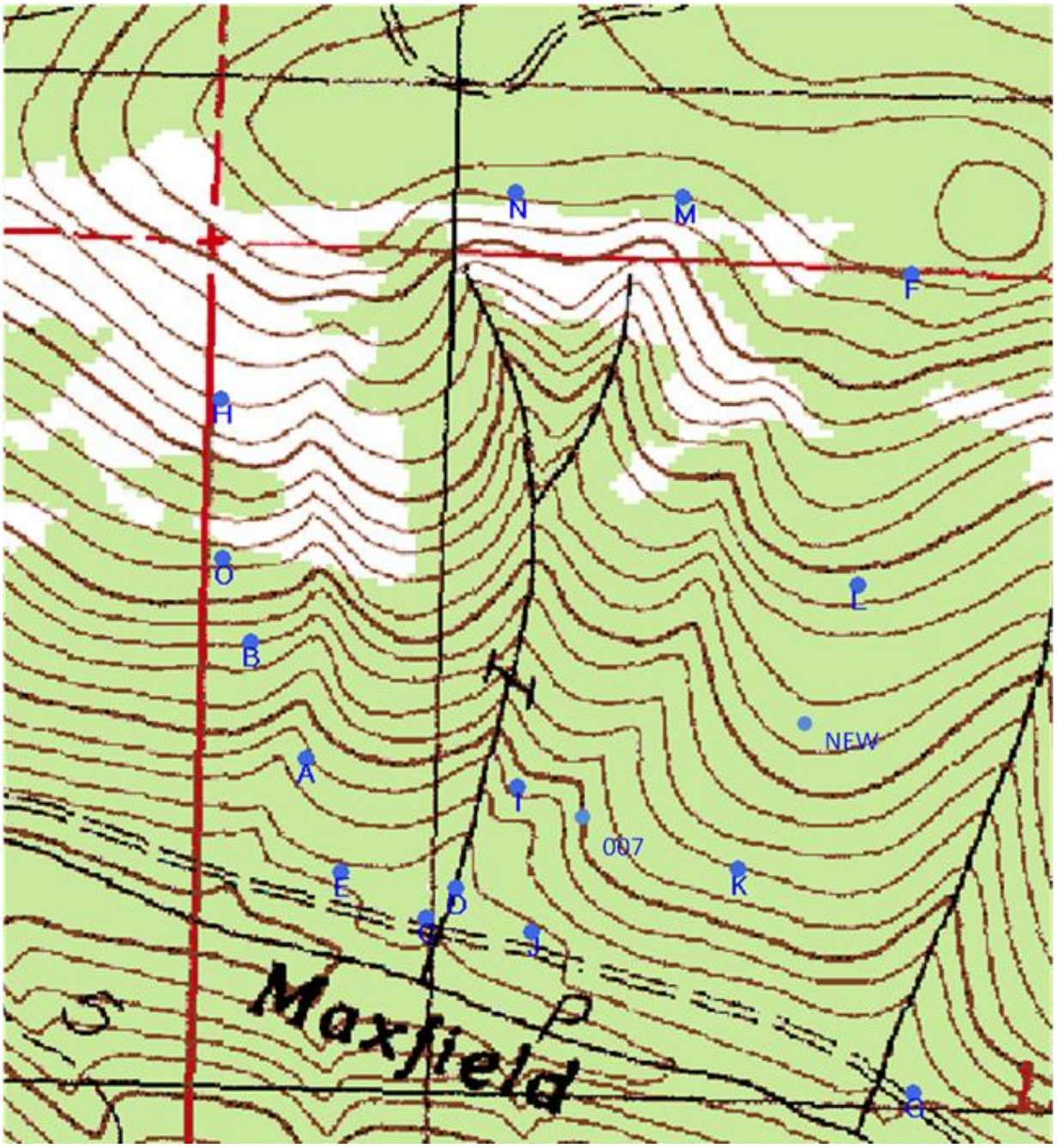

FIGURE 10. TOPOGRAPHIC MAP OF BRACHYPODIUM SYLVATICUM CONTROL AREAS AT MAXFIELD MEADOWS. LETTERS REFER TO PATCHES DESCRIBED IN TABLE 5. CIRCLES REPRESENT POINTS IN THE CENTER OF EACH PATCH AND ARE NOT TO SCALE.

In March 2010, we observed no *Brachypodium* seedlings in previously treated patches, A, C, D, E, F, H, I, J, K, L, M, N, and O. We also observed several seedlings that appeared to be of the species included in our seed mixes and distributed in fall 2009. Unfortunately in June 2012, a handful of *Brachypodium* plants were found and removed at Patch C.

Site B is a large infested area near the private timber land/BLM boundary. This area was previously sprayed and has since been revisited a number of times to pull plants that were missed or have since germinated. The remaining plants are mostly scattered and hiding in inconspicuous spots (within shrubs and under trees). We pulled approximately 2 trash bags of plants in March 2010. It is recommended that the area be revisited in 2013 or 2014 to assess the effectiveness of control measures in the area.

In March 2010, we found a new patch of *Brachypodium* between sites K and L. This site includes a concentrated patch approximately 3m x 3m as well as individuals scattered through the area. Poison-oak is relatively dense in this area. This site was sprayed with glyphosate in April 2011. It is recommended that the area be revisited in the spring of 2013 or 2014 to check for remaining plants.

An additional patch of *Brachypodium,* 007, was located between patches I and K during fall scouting in 2010. This patch was sprayed with glyphosate in April 2011. The area should be revisited and the remaining individuals pulled.

Site G is located just after a borrow pit on the upslope side of the road. We walked up an old skid road and found a large, seemingly isolated population in and adjacent to the drainage, on a leveled landing where either logging machinery was parked or logs were loaded from the previous timber harvest, and in a small area of the skid road. We removed all the plants present in this area in March 2010 (approximately 10 large trash bags). We revisited this site in spring 2011, and pulled four more bags. We observed *Brachypodium* (adults and seedlings) growing both on the stream banks and in the stream itself (submerged in water). This area will likely require continued control for several years. This area was revisited in the spring of 2012 and an additional 12 large garbage bags (approximately 60-80cubic feet) were removed. We will revisit this site again in spring 2013

In March 2010, we also observed *Brachypodium* above G, along the skid road, and east into the drainage. *Brachypodium* has evidently washed down the drainage and was present adjacent to the stream and scattered all over the floodplain terrace of Maxfield Creek below the road, and on to the east side of the stream. In late March 2010, we pulled approximately 20-25 cubic feet of *Brachypodium* from his area. The water level in the stream was very high, and we probably missed several seedlings and adults within the drainage. We returned to this area in spring 2011 and pulled six bags of false-brome. The area was revisited in the spring of 2012 and 15-20 cubic feet of material was removed from the stream terrace below the road. We will revisit this area several times in the future, to pull remaining plants and new seedlings. The area is also infested with *Geranium robertianum*, from the purported landing above the road (where we pulled on 3/18/10) to throughout the floodplain terrace above Maxfield Creek. The perimeters of the areas where *Brachypodium* was pulled were marked with yellow flagging either around tree trunks or hanging off of tree limbs.

In late 2009/early 2010, a patch of *Brachypodium* was identified near the Pit Road meadow. This patch is approximately 150 feet from the edge of the meadow, near the East and North property boundaries.

Scouting in spring 2011 identified seven patches along the trail in the forested area (Figure 11). These areas were sprayed with glyphosate in April 2011. Several other patches of false-brome found uphill from the BLM property boundary may contribute to the seed bank in the area. We will revisit these areas in spring 2013 to pull remaining plants and check for new populations on BLM property.

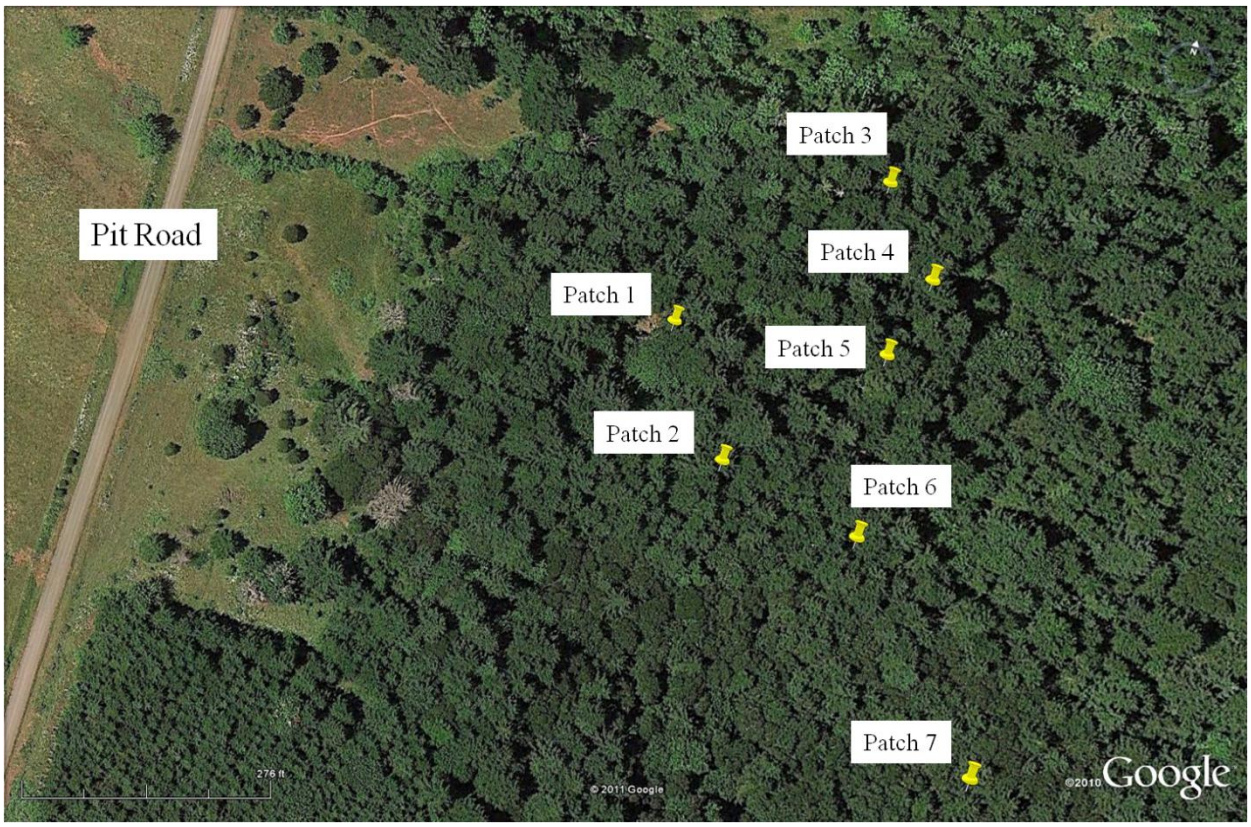

FIGURE 11. LOCATION OF SEVEN *BRACHYPODIUM SYLVATICUM* PATCHES EAST OF PIT ROAD MEADOW. THESE AREAS WERE SPRAYED WITH GLYPHOSATE IN SPRING 2011.

XERIC MEADOW RESTORATION

Introduction

Currently, the quality of the meadow habitat in the 10-5-19 meadows is relatively low (Figure 12). As the abundance of native species has been relatively low now for several years, it is likely that few seeds have been produced, particularly relative to exotic species. Without the addition of native seed, it is likely that cover of native species will continue to decline.

FIGURE 12. THE UPPER 10-5-19 MEADOWS ARE CHARACTERIZED BY SHALLOWER, ROCKY SOILS AND RELATIVELY HIGH COVER OF EXOTIC SPECIES.

Another potential problem in these meadows is inhibition of native seedling germination and growth. In the absence of disturbances such as fire, vigorous growth by exotic species has resulted in a thick thatch layer that is likely to suppress seedling establishment.

A third issue affecting the restoration potential of the upper meadows is the competitive ability of native species. Several studies have shown that addition of carbon as either sugar or sawdust can increase the competitive ability of native plants species relative to exotic species (Corbin and D'Antonio, 2004; Kirkpatrick et al. 2006). By stimulating microbial activity, carbon addition limits the amount of soil nutrients available for plant growth (particularly nitrogen and phosphorus). This method is currently being tested in the xeric meadows at Horse Rock Ridge ACEC, managed by the Eugene District BLM.

We propose to test three methods to increase the cover of native species in the xeric meadows by increasing the abundance of native seeds, decreasing thatch, and applying carbon to decrease the competitive ability of exotic species.

Methods

In September 2009, we established 15 5m x 5m treatment plots arranged in four blocks (Figure 13) in the 10-5-19 East Meadow (T10 R05W Sec. 19 N 1/2). Two blocks were composed of 5 plots each. The third block was split into two separate blocks of 3 and 2 plots, due to space constraints in the meadow, but will be considered as one unit. All plots were situated so that they did not include any of the areas where slash was previously piled and burned. Plots 101-105 (Lower Meadow) are lowest in the meadow (elevationally), near several young *Pseudotsuga menziesii* that will be cut during the timber harvest associated with meadow and oak restoration. Plots 106-110 (Middle Meadow) are less affected by the canopy cover of surrounding trees except for a large *P. menziesii* above plots 108 and 109. Plots 111-115 (Upper Meadow) are the farthest upslope; a large *P. menziesii* is situated upslope of plot 112. Plot 113 unavoidably contains the start of a vegetation transect, marked by a long white fiberglass post.

Table 7. Treatments used in xeric meadow restoration experiment.

Treatment	Plot Numbers
Burn + Seed	105, 109, 891
Control	102, 108, 111, 115
Rake + Seed	104, 106, 112
Seed	101, 107, 113
Sugar + Seed	103, 110, 114

All plots were monumented in their NW and SE corners with rebar (pounded into ground so that ~1' visible) and in their NE and SW corners with 8" metal spikes (pounded into ground so that ~1" visible). Plots were 5m x 5m and oriented such that the top edge was perpendicular to the slope's aspect. Aluminum tags with unique numbers were wired onto the NW rebar in each plot.

Within each block, plots with trees upslope and/or with stumps were excluded as potential burn plots; the burn treatment was randomly assigned to one of the remaining plots (Table 7). Plots 109 and 105 were chosen from the first and second blocks, but since all of the plots in the split block were in the shade and not expected to burn well, a third burn plot (number 891) was constructed between the first and second blocks. Because this extra plot was added, one of the control plots from the third block (115) was randomly excluded from the analysis). The remaining 4 treatments were assigned randomly to the remaining plots within each block. A meter-wide buffer was weed-whacked into the meadow (clearing all vegetation down to ground level) around every plot. All of the cut vegetation (per block of 5 plots) was raked and piled up at the downslope edge of each burn plot in that block. An additional meter was mown into the prairie on the upslope side of the burn plot, creating a 2 meter burn buffer. Downed woody material in the buffer zones around the plots was moved to the meadow edge to facilitate mowing. Woody material was also removed from burn plots to facilitate burning.

Burn plots were treated November 4, 2009 using a propane torch. Each plot took less than 5 minutes to burn and was out after 10 minutes; no smoldering material was present in any plot. Flame reached approximately 2ft. height. Overall, the fire burned away the standing dead vegetation but left the ground surface more or less undamaged (Figure 14). A healthy exotic forb layer consisting of *Hypochaeris radicata* and *Leucanthemum vulgare* dominated the burned plots and did not appear to be affected by the fire although a few patches of the ground surface burned at a higher intensity and were left with no litter or vegetation.

The remaining treatments were implemented November 5, 2009 (Figure 14). Control plots were undisturbed. Rake + seed plots were first raked free of any loose litter and/or vegetation with a metal rake (see photos) and then seeded. This treatment led to ~10-20% disturbed soil in each and little standing litter. The exotic forb layer prevented further ground disturbance. Seed plots were only seeded; otherwise they were left unmanipulated. Burn plots also seeded. Sugar + seed plots were first seeded and then covered evenly with 110 pounds carbon (2 kg m^{-2} as granulated sugar).

Treatment plots was monitored May 26, 2010. A $1m^2$ plot was tossed haphazardly near the center of each plot. Percent aerial cover of all species and ground cover was recorded.

Data Analysis

We analyzed the effects of treatment on the total cover of native and exotic species, the cover of native forbs, and litter, using ANOVA on arcsin-square root transformed data to meet assumptions of normality. Non-significant treatment levels were collapsed to improve statistical power as long as doing so did not worsen the model fit to the data (Crawley 2007). All analyses were performed in R 2.11 (R core development team, www.cran-r.org).

Results

We found 47 species in the experimental plots, 22 native, 24 exotic, and 1 unknown (Appendix D). Exotic cover did not differ between treatments (Figure 15a, $F_{4,10} = 1.27$, $P = 0.34$). Native cover was highest in the Burn + Seed treatment, when compared against all others (Figure 15a, $F_{1, 13} = 6.46$, $P = 0.025$). This increase was due to an increase in native forbs in the Burn + Seed treatment compared to all other treatments (Figure 15b, $F_{1,13} = 1.26$, $P = 0.06$). The number of native and exotic species did not differ between treatments ($P > 0.15$). Litter was significantly lower in the Burn + Seed treatment when compared to all other treatments (Figure 15c , $F_{1, 13} = 7.29$, $P = 0.018$).

The native species that increased the most in the Burn + Seed treatment were *Achillea millefolium*, *Elymus glaucus*, and *Prunella vulgaris*; these were all seeded species (Appendix D). Other seeded species either did not establish, were as yet indistinguishable from other species (e.g., some grass seedlings may have not been correctly identified), or established in low numbers.

FIGURE 13. XERIC MEADOW RESTORATION TREATMENT TRIAL PLOTS SHOWING APPROXIMATE LOCATIONS OF PLOTS. NOTE THAT SEVERAL TREES HAVE BEEN REMOVED SINCE THIS PHOTO WAS TAKEN.

FIGURE 14. XERIC MEADOW RESTORATION TREATMENT PLOTS THE DAY OF TREATMENT (EXCEPT BURN PLOTS WHICH WERE TREATED THE PREVIOUS DAY). TOP LEFT: CONTROL PLOT. TOP RIGHT: BURN PLOT; NOTE THE REMAINING GREEN VEGETATION. BOTTOM LEFT: CARBON ADDITION PLOT. BOTTOM RIGHT: RAKED PLOT. ALL TREATMENT PLOTS PLUS AN ADDITIONAL PLOT IN EACH BLOCK WAS SEEDED WITH A MIX OF NATIVE GRASSES AND FORBS.

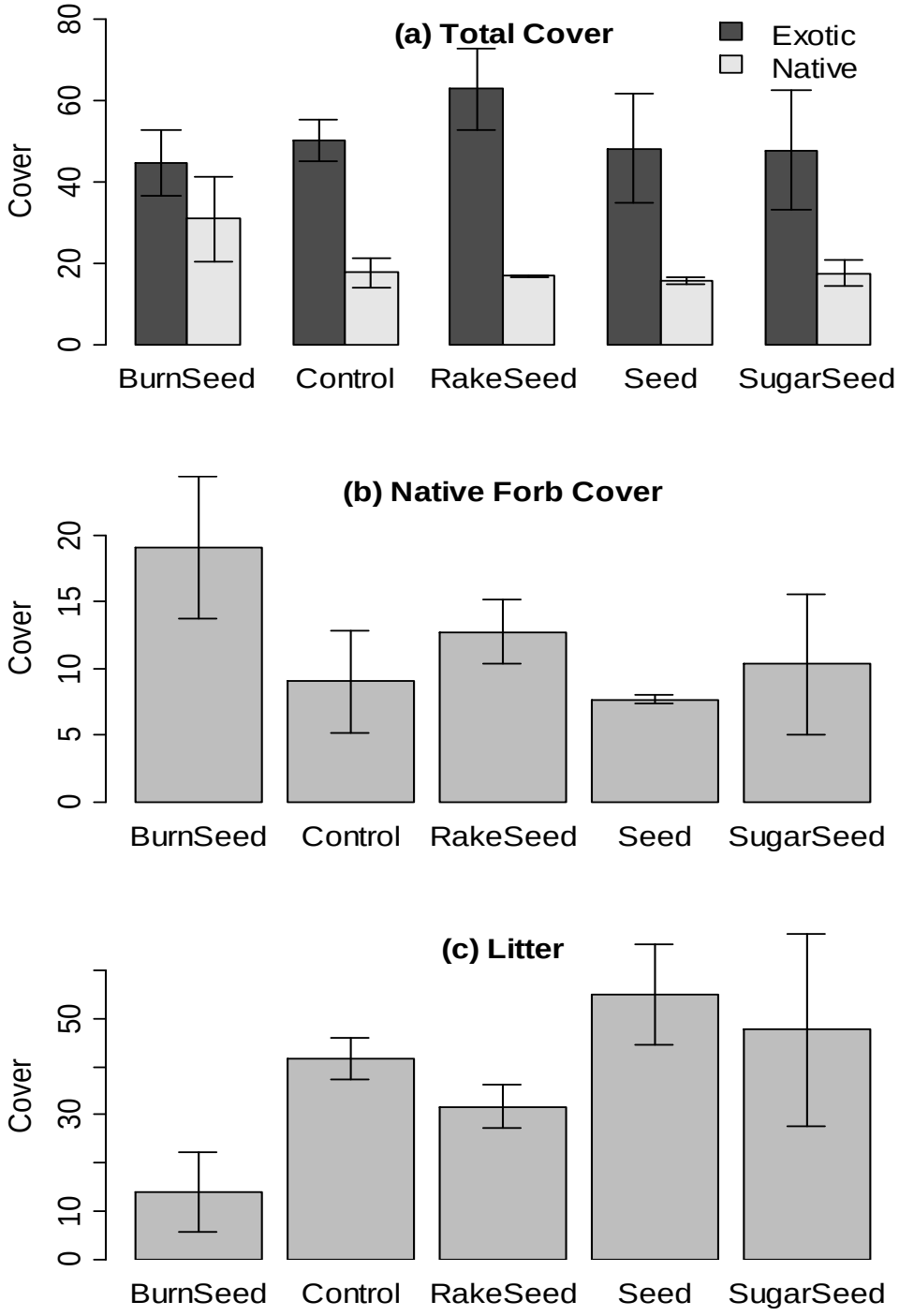

FIGURE 15. COVER OF EXOTIC AND NATIVE SPECIES (A), NATIVE FORBS (B), AND LITTER (C) IN THE XERIC MEADOW RESTORATION EXPERIMENT. DATA ARE MEANS ± 1 SE.

Discussion

Burning + Seeding was the most successful in terms of decreasing litter and increasing native cover, although native diversity did not increase and exotic cover remained high. Native forbs were responsible for most of the boost in total native cover, although one grass, *Elymus glaucus,* increased in this treatment. We did not see substantial changes in any other functional groups with treatment; exotic annuals did not increase in the burn plots, as may have been expected given other studies (Stanley et al 2011). Sugar addition has not yet led to changes in the plant community, and did not seem to encourage greater establishment from native seed. The thick cover of thatch likely inhibited seed establishment; combining the Burn + Seed with a sugar addition may prove more beneficial.

Burning was the only treatment which significantly reduced litter. While raking caused some decline in litter (Figure 15c), this decline was not significant, and did not lead to good establishment by seeded species. Burning may be advantageous over raking for a number of reasons. Burning created substantially more bare soil than raking, and bare soil has been shown to be key for seedling germination in many studies (Stanley et al 2011). Many native species germinate better with smoke cues; burning may also sterilize the soil, reducing detrimental soil biota.

In summary, prescribed fire followed by heavy seeding of native species may be successful in increasing native cover in the dry prairies at Maxfield Meadows. Although exotic species cover has not yet been affected, we may observe changes over time through the increased cover by native species.

OAK SAVANNAH RESTORATION

Introduction

A selective timber harvest is currently planned for summer 2013. This will be followed by fall brush clearing, pile burns in 2013/2014, and a broadcast burn in 2015. Disturbed areas will be seeded with native forbs and grasses after pile burns. After the broadcast burn in 2015, will heavily seed burned areas with native forbs and grasses. These treatments have been postponed for several years due primarily to low timber prices. The goal of our project post timber-harvest is to facilitate restoration of this area to an oak savannah dominated by native species. There are several potential issues to be addressed in this restoration:

- Increased potential of invasion by exotic species, due to disturbance from logging activities and potential for introduction of seeds or plant parts on logging equipment.
- Lack of native seed inputs due to low cover of appropriate native species in the vicinity of the treatment area.
- Litter in the harvested areas is of a different quality and quantity of litter in native oak savannahs.

- Soil processes may be different than in a native oak savannah due to differences in quality and quantity of litter inputs.

Future activities

There will be two years of pile burning immediately following the end of the timber harvest (2013/2014). Disturbed areas after these burns will be seeded in November of that year. In the fall following the broadcast burn (2015), we will seed all affected areas with a sun and edge mix composed of species collected at Maxfield Meadows. Each spring, we will survey the treated area for exotic plant species (Table 8). We will remove Scotch broom (*Cytisus scoparius*) which is quite widespread in the project area, Himalayan blackberry and evergreen blackberry (*Holodiscus discolor* and *laciniatus*, respectively), false brome (*Brachypodium sylvaticum*), and Meadow knapweed (*Centaurea pratense*) as possible using mechanical methods. If any patches are too large to feasibly remove by hand, we will consult with BLM staff regarding other control options. In spring 2014, we will survey seeded areas for germination and establishment of seeded species. As necessary, these activities will be repeated.

TABLE 8. PLANNED ACTIVITITES AT MAXFIELD MEADOWS THROUGH 2017. ACTIONS SCHEDULED ARE DEPENDENT ON POST-TIMBER HARVEST CONDITION, FUNDING AND PERSONNEL. ACTIVITIES WILL BE IN COORDINATION WITH SALEM BLM STAFF.

Task	Month	Year
Noxious Weed Treatment	April	2013
Pile burning	Fall	2013
Seed disturbed areas	November	2013
Noxious weed treatment	Spring	2014
Qualitative surveys of 2013 seeding	Spring	2014
Seed pile burn sites	November	2014
Broadcast burn	Spring	2015
Noxious Weed Treatment	Spring	2015
Seed burn areas	Fall	2015
resample Salix transects	Spring	2016
Kincaid lupine monitoring plan	Spring	2016
Plant oak seedlings	February	2016
Seed, monitor, noxious weed control		2017

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Appendix A. Cover (%) of all species found on transects in each surveyed meadow in June 2008. "Ave." is the average cover value for the two transects in each meadow.

	East Meadow			Middle Meadow			West Meadow			Pit Road Meadow		
	E1	**E2**	**Ave.**	**M1**	**M2**	**Ave.**	**W1**	**W2**	**Ave.**	**PR1**	**PR2**	**Ave.**
Exotic Forb												
Cerastium glomeratum	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cirsium vulgare	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.3	0.0	0.0	0.0
Crepis capillaris	10.3	14.2	12.3	3.9	1.6	2.8	15.3	4.2	9.8	0.0	0.0	0.0
Galium parisiense	0.0	0.0	0.0	0.2	0.2	0.2	0.3	0.2	0.2	0.9	0.1	0.5
Hypericum perforatum	0.1	0.3	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.3
Hypochaeris radicata	0.0	0.0	0.0	0.0	4.2	2.1	0.1	0.2	0.1	0.0	0.0	0.0
Lathyrus sphaericus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Leucanthemum vulgare	6.7	2.7	4.7	0.0	0.0	0.0	0.0	0.0	0.0	27.5	2.0	14.8
Plantago lanceolata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1
Rumex acetosella	0.2	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Senecio jacobaea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0
Sherardia arvensis	2.2	2.0	2.1	0.0	0.3	0.1	0.8	0.2	0.5	0.1	0.1	0.1
Sonchus asper	0.7	0.7	0.7	0.0	0.0	0.0	0.4	0.0	0.2	0.0	0.0	0.0
Torilis arvensis	6.6	2.0	4.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1
Tragopogon dubius	0.0	0.0	0.0	0.0	1.2	0.6	0.0	0.0	0.0	0.0	0.0	0.0
Trifolium dubium	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Veronica arvensis	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Vicia cracca	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.2	0.3
Vicia hirsuta	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Vicia sativa	1.6	0.1	0.9	0.0	0.0	0.0	0.4	2.2	1.3	0.5	0.0	0.3
Richness	8.0	9.0	10.0	3.0	5.0	6.0	6.0	7.0	8.0	6.0	7.0	9.0
Average cover	1.4	1.1	1.3	0.2	0.4	0.3	0.9	0.4	0.6	1.5	0.2	0.8
Total cover	28.3	22.0	25.1	4.1	7.4	5.8	17.2	7.7	12.4	29.5	3.1	16.3

Appendix A, cont.. Cover (%) of all species found on transects in each surveyed meadow in June 2008. "Ave." is the average cover value for the two transects in each meadow.

	East Meadow			Middle Meadow			West Meadow			Pit Road Meadow		
	E1	**E2**	**Ave.**	**M1**	**M2**	**Ave.**	**W1**	**W2**	**Ave.**	**PR1**	**PR2**	**Ave.**
Exotic Graminoid												
Agrostis sp.	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.7	0.0	0.4
Aira caryophyllea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Arrhenatherum elatius	0.0	0.0	0.0	16.9	0.9	8.9	2.6	6.1	4.3	30.0	3.0	16.5
Bromus diandrus	3.2	0.9	2.0	9.9	0.0	5.0	14.1	5.4	9.8	0.0	0.0	0.0
Bromus hordeaceus	3.0	3.8	3.4	2.7	1.1	1.9	11.5	0.5	6.0	0.0	0.0	0.0
Cynosurus echinatus	18.3	10.0	14.2	1.6	4.1	2.8	4.1	7.0	5.6	0.2	0.1	0.1
Dactylis glomerata	0.0	0.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.6	9.3
Festuca arundinacea (*Schedonorus phoenix*)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.0	8.0
Holcus lanatus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.0
Poa compressa	0.0	2.6	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Poa pratensis	0.1	0.6	0.3	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0	0.8
Taeniatherum caput-medusae	1.9	0.0	0.9	5.9	0.0	3.0	7.0	0.0	3.5	0.0	0.0	0.0
Vulpia bromoides	0.2	0.0	0.1	10.1	0.0	5.1	18.3	0.3	9.3	0.0	0.0	0.0
Richness	6.0	6.0	8.0	6.0	4.0	7.0	6.0	6.0	7.0	5.0	4.0	7.0
Average cover	2.0	1.4	1.7	3.6	0.5	2.0	4.4	1.5	3.0	2.5	2.9	2.7
Total cover	26.6	18.3	22.4	47.1	6.1	26.6	57.5	19.5	38.5	32.4	37.7	35.1
Exotic Tree/Shrub												
Rosa eglanteria	7.3	0.0	3.7	0.0	0.0	0.0	0.0	0.0	0.0	2.2	10.6	6.4
Richness	1.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0
Average cover	7.3	0.0	3.7	0.0	0.0	0.0	0.0	0.0	0.0	2.2	10.6	6.4
Total cover	7.3	0.0	3.7	0.0	0.0	0.0	0.0	0.0	0.0	2.2	10.6	6.4

Appendix A, cont.. Cover (%) of all species found on transects in each surveyed meadow in June 2008. "Ave." is the average cover value for the two transects in each meadow.

	East Meadow			Middle Meadow			West Meadow			Pit Road Meadow		
	E1	**E2**	**Ave.**	**M1**	**M2**	**Ave.**	**W1**	**W2**	**Ave.**	**PR1**	**PR2**	**Ave.**
Native Forb												
Achillea millefolium	0.0	0.7	0.4	0.0	0.0	0.0	0.0	0.4	0.2	2.3	0.0	1.2
Agoseris grandiflora	1.7	1.8	1.7	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Brodiaea elegans	0.0	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0
Clarkia purpurea	0.0	0.0	0.0	0.9	0.0	0.4	1.7	1.0	1.3	0.0	0.0	0.0
Claytonia perfoliata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.0
Collinsia grandiflora	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.1	0.0	0.0	0.0
Collomia grandiflora	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.3	0.0	0.0	0.0
Daucus pusillus	0.4	0.0	0.2	4.0	0.0	2.0	4.0	0.1	2.0	3.7	0.9	2.3
Dichelostemma congestum (*Brodiaea congesta*)	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Epilobium brachycarpum	0.1	0.1	0.1	3.0	1.3	2.1	1.1	0.6	0.8	0.0	0.0	0.0
Equisetum spp.	0.0	0.8	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eriophyllum lanatum	0.7	0.3	0.5	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0
Fragaria virginiana	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.0	10.8	14.9
Galium aparine	0.2	0.6	0.4	0.0	0.0	0.0	0.0	0.5	0.3	0.0	5.6	2.8
Lonicera hispidula	2.9	1.2	2.0	0.0	2.4	1.2	0.0	0.0	0.0	0.0	0.0	0.0
Lotus micranthus	0.1	0.3	0.2	0.6	9.6	5.1	0.0	0.4	0.2	0.0	0.0	0.0
Lotus unifoloiolatus (*Lotus purshianus*)	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Madia gracilis	3.5	0.8	2.2	0.1	14.5	7.3	0.0	0.2	0.1	0.0	0.0	0.0
Marah oregana	2.1	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Myosotis discolor	0.1	0.2	0.1	0.0	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.0
Nemophila parviflora	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	1.0	0.0	0.1	0.1
Osmorhiza chilensis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.3
Plagiobothyrus nothofulvus	0.0	1.4	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Prunella vulgaris var. vulgaris	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.3
Pteridium aquilinum var. pubescens	1.9	0.9	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ranunculus occidentalis	0.1	1.3	0.7	0.0	1.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0
Sanicula crassicaulis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.3
Sidalcia sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Richness	12.0	16.0	18.0	5.0	6.0	8.0	4.0	13.0	14.0	4.0	6.0	8.0
Average cover	0.5	0.4	0.4	0.3	1.0	0.7	0.2	0.2	0.2	0.9	0.7	0.8
Total cover	13.8	10.7	12.2	8.5	28.9	18.7	6.9	6.5	6.7	25.6	18.5	22.0

Native Graminoid

Achnatherum lemmonii (Stipa lemmonii)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.3	0.0	0.0	0.0
Bromus sitchensis	2.4	9.9	6.1	0.0	8.3	4.2	0.0	0.1	0.1	1.1	0.0	0.6
Carex tumulicola	0.0	0.8	0.4	0.0	0.0	0.0	0.0	0.0	0.0	1.7	1.6	1.6
Danthonia californica	0.0	3.3	1.7	0.0	2.4	1.2	0.0	1.6	0.8	0.0	0.0	0.0
Elymus glaucus	1.7	0.2	0.9	1.6	0.6	1.1	0.3	1.7	1.0	0.0	0.2	0.1
Luzula comosa	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Richness	2.0	4.0	4.0	1.0	3.0	3.0	1.0	5.0	5.0	2.0	2.0	3.0
average cover	0.7	2.4	1.5	0.3	1.9	1.1	0.1	0.7	0.4	0.5	0.3	0.4
Total cover	4.1	14.2	9.1	1.6	11.3	6.4	0.3	3.9	2.1	2.8	1.8	2.3

Appendix A, cont. Cover (%) of all species found on transects in each surveyed meadow in June 2008. "Ave." is the average cover value for the two transects in each meadow.

	East Meadow			Middle Meadow			West Meadow			Pit Road Meadow		
	E1	**E2**	**Ave.**	**M1**	**M2**	**Ave.**	**W1**	**W2**	**Ave.**	**PR1**	**PR2**	**Ave.**
Native Tree/Shrub												
Acer macrophyllum	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	1.2
Fraxinus latifolia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.4	0.3
Quercus garryana (aerial)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Quercus garryana (ground)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.3
Toxicodendron diversilobum	26.2	0.0	13.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	22.2	11.1
Richness	1.0	1.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	4.0	4.0
average cover	5.2	0.0	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.1	2.6
Total cover	26.2	0.1	13.2	0.0	0.0	0.0	0.0	0.0	0.0	0.1	25.5	12.8
Exotic/Native Graminoid												
Festuca rubra	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.4	0.0	0.2

Appendix B. Average cover of species located on burn piles seeded in 2007.

Species	Form	Nativity	Propagule type	Average Cover (%) of burn piles	
				West Meadow	East Meadow
Cirsium vulgare	Forb	Exotic	Natural recruit	0	0.4
Sherardia arvensis	Forb	Exotic	Natural recruit	0	0.2
Vicia sativa	Forb	Exotic	Natural recruit	0	0.2
Cynosaurus echinatus	Grass	Exotic	Natural recruit	0	0.2
Lolium perenne	Grass	Exotic	Natural recruit	0	0.2
Achillea millefolium	Forb	Native	Seed mix	10.4	14.1
Brodiaea coronaria	Forb	Native	Plug	0.1	0.1
Clarkia purpurea	Forb	Native	Seed mix	4.6	6.2
Collinsia grandiflora	Forb	Native	Seed mix	4.6	6.5
Collomia grandiflora	Forb	Native	Seed mix	4.6	3.9
Eriophyllum lanatum	Forb	Native	Seed mix	2.1	2.4
Iris tenax	Forb	Native	Seed mix	0	0
Lomatium utriculatum	Forb	Native	Seed mix	0.1	0.2
Lotus micranthus	Forb	Native	Natural recruit	0	0.2
Lupinus rivularis	Forb	Native	Seed mix	0.1	0.4
Madia elegans	Forb	Native	Seed mix	1.4	0.5
Madia gracilis	Forb	Native	Seed mix	0.7	8.7
Plagiobothrys nothofulvus	Forb	Native	Seed mix	0	0
Potentilla spp.	Forb	Native	Seed mix	0.3	0.1
Prunella vulgaris var *lanceolata*	Forb	Native	Seed mix	0.4	0.8
Pteridium aquilinum	Forb	Native	Natural recruit	0	0.1
Sidalcea malviflora	Forb	Native	Seed mix	0.4	0.4
Trifolium cf. *willdenovii*	Forb	Native	Natural recruit	0.1	0.3
Wyethia angustifolia	Forb	Native	Plug	0.1	0
Achnatherum lemmonii	Grass	Native	Seed mix	0	0
Bromus sitchensis	Grass	Native	Seed mix	17.4	3.9
Elymus glaucus	Grass	Native	Seed mix	17.8	16.8
Festuca californica	Grass	Native	Seed mix	0.3	0
Festuca roemeri	Grass	Native	Seed mix	9.0	25.7
Koeleria macrantha	Grass	Native	Seed mix	0	0

Appendix C. Modified shade mix distributed in *Brachypodium* control areas.

Species	Growth form	Longevity	Seeds lb^{-1}	Weight (lb.)
Species in edge mix from Heritage Seedlings, Inc.				10
Bromus vulgaris	grass	perennial	71,000	
Elymus glaucus	grass	perennial	120,000	
Festuca californica	grass	perennial	450,000	
Festuca roemeri	grass	perennial	500,000	
Koeleria macrantha	grass	perennial	2,000,000	
Achillea millefolium	forb	perennial	1,418,947	
Clarkia purpurea	forb	annual	1,890,000	
Collinsia grandiflora	forb	annual	464,687	
Collomia grandiflora	forb	annual	121,715	
Eriophyllum lanatum	forb	perennial	1,169,047	
Iris tenax	forb	perennial	46,000	
Madia elegans	forb	annual	213,145	
Prunella vulgaris var. *lanceolata*	forb	perennial	1,418,947	
Sidalcea malviflora	forb	perennial	1,418,947	
Additional species added				
Aquilegia formosa	forb	perennial	248,000	0.575
Ligusticum apiifolium	forb	perennial	120,000	1.6
Bromus vulgaris	grass	perennial	71,000	10
Prunella vulgaris var. *lanceolata*	forb	perennial	1,418,947	1.1

Appendix D. Average cover (%) of all species and ground cover in xeric meadow restoration experiment, 2010.

Species	Group	Native?	Duration	Burn + Seed	Control	Rake+ Seed	Seed	Sugar + Seed
*Achillea millefolium**	Forb	Native	Perennial	2.33	0.67	0.67	1.33	0.17
Agoseris grandiflora	Forb	Native	Perennial	1.67	0.67	0	0	0.17
Apocynum adrosaemifolium	Forb	Native	Perennial	1	0.37	0.7	2	0.67
Brodiaea spp.	Forb	Native	Perennial	0.03	0	0	0	0
*Collinsia grandiflora**	Forb	Native	Annual	0.33	0	0	0.03	0.17
*Eriophyllum lanatum**	Forb	Native	Perennial	6.03	4	8.33	1.67	8
*Lomatium utriculatum**	Forb	Native	Perennial	0	0.33	0	0	0
Lotus unifoloiolatus	Forb	Native	Annual	1.03	0.67	0.37	1.67	4.07
*Madia spp.**	Forb	Native	Annual	0	0.33	3.33	0.33	0.67
*Prunella vulgaris**	Forb	Native	Perennial	6	0	1.33	0.33	0
Ranunculus occidentalis	Forb	Native	Perennial	2	2.33	1.33	1.67	1.33
Sanicula bipinnatifida	Forb	Native	Perennial	0	0	0.33	0.67	0
*Sidalcia virgata**	Forb	Native	Perennial	0	0.67	0	0	0
Bromus sitchensis	Grass	Native	Perennial	4	2	0.33	4.33	1.33
Danthonia californica	Grass	Native	Perennial	0.33	3	0	0	0
Elymus glaucus	Grass	Native	Perennial	4.67	1.33	0	1	0.33
Festuca roemeri	Grass	Native	Perennial	0	0.33	0	0	0.33
Luzula comosa	Grass	Native	Perennial	0.03	0	0	0	0
Marah oregana	Shrub	Native	Perennial	0	1	0	0.67	0.17
Pseudotsuga menzeisii	Shrub	Native	Perennial	0	0	0	0.03	0
Quercus garryana	Shrub	Native	Perennial	0	0	0	0	0.03
Toxicodendron diversilobum	Shrub	Native	Perennial	1.33	0	0	0	0
Cerastium glomeratum	Forb	Exotic	Annual	0.03	0.37	0.67	0.03	0.2
Crepis capillaris	Forb	Exotic	Biennial	8.33	5.67	2.67	3.33	9.33
Daucus/Torilis	Forb	Exotic	Biennial	2.67	4.67	6.67	1.33	1.37
Geranium spp.	Forb	Exotic	Annual	0.67	2.33	9.67	10.67	1
Hypericum perforatum	Forb	Exotic	Annual	0.17	0	0	0	0
Hypochaeris radicata	Forb	Exotic	Biennial	4.67	2.67	2.67	2.33	9.33
Leucanthemum vulgare	Forb	Exotic	Perennial	12.33	5	8	8.67	9
Myosotis discolor	Forb	Exotic	Annual	0.03	0.33	0	0.33	0
Senecio jacobaea	Forb	Exotic	Perennial	0.67	0	0	0.67	0
Sherardia arvensis	Forb	Exotic	Annual	0.23	0.07	0.07	0.33	0.07
Sonchus asper	Forb	Exotic	Annual	1	0.33	0	0.33	0.33
Tragopogon dubius	Forb	Exotic	Annual	0	0.33	0.67	0	0.33
Vicia hirsuta	Forb	Exotic	Annual	0	0.03	0	0	0
Vicia sativa	Forb	Exotic	Annual	0.17	0.1	0.7	0.7	0.07
unk. Forb	Forb	Unknown	Unknown	0	0	0	0	0.03

Agrostis sp.	Grass	Exotic	Perennial	0.33	0	0	0.33	0
Arrhenatherum elatius	Grass	Exotic	Perennial	0	1.33	5.67	0	2.67
Bromus diandrus	Grass	Exotic	Annual	3.33	1	0.67	0.33	0.33
Bromus hordeaceus	Grass	Exotic	Annual	8	24.33	23.33	16.67	6.67
Cynosurus echinatus	Grass	Exotic	Annual	1.67	0.67	0.33	0.03	7
Festuca arundinaceae	Grass	Exotic	Perennial	0	0	0	0.67	0

Appendix D, cont. average cover of all species and ground cover in xeric meadow restoration experiment, 2010

Species	Group	Native?	Duration	Burn + Seed	Control	Rake+ Seed	Seed	Sugar + Seed
Poa compressa	Grass	Exotic	Annual	0	0.67	1	0.67	0
Poa pratensis	Grass	Exotic	Perennial	0	0	0	0.67	0
Rosa eglanteria	Shrub	Exotic	Perennial	0.33	0	0	0	0
Rubus armeniacus	Shrub	Exotic	Perennial	0	0.33	0	0	0
bare ground	--	--	--	43.33	41.67	50	29.33	39.33
dead wood	--	--	--	0	0.33	0	0	0
litter	--	--	--	14	41.67	31.67	55	47.67
moss	--	--	--	0	0	0	0	0
rock	--	--	--	0	0	0	0	0.67