

Horse Rock Ridge Assessment, Seed Collection, and Restoration



2012 &
2013

Report to the Bureau of Land Management,
Eugene District

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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: Upper meadow at Horse Rock Ridge.

All photos by IAE unless otherwise stated.

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REPORT TO THE BUREAU OF LAND MANAGEMENT, EUGENE DISTRICT

INTRODUCTION

Project Overview

This report describes actions taken in 2012 and 2013 as part of a multi-year project at Horse Rock Ridge Area of Critical Environmental Concern/Research Natural Area (ACEC/RNA). The purpose of this project is to assess the current condition of high-priority ecosystems at Horse Rock Ridge, prioritize native plant communities and invasive species for management action, collect seeds for restoration, and initiate site restoration.

Site description

The following description of Horse Rock Ridge is taken largely from Sawtelle 2006.

Horse Rock Ridge ACEC/RNA is a 378-acre (153-ha) area located in Linn County within the Upper Willamette Resource Area. The site is within the Coburg Hills on the divide between the Calapooya and Mohawk River drainages on the eastern edge of the Willamette Valley in western Oregon. Horse Rock Ridge was designated an Area of Critical Environmental Concern (ACEC) in 1984 and a Research Natural Area (RNA) in 1995. This protection was given primarily to preserve an example of a grassy bald (treeless area) and forest mosaic on the western margin of the Cascade Mountains.

The topography of Horse Rock Ridge is rugged with rock outcroppings and steep slopes. Approximately two-thirds of the area has a southern exposure; the rest of the area lies on a north slope. The elevation of Horse Rock Ridge ranges from 1,550 to 2,864 feet.

Horse Rock Ridge fills the natural area cell or element described in the Oregon Natural Heritage Plan (2003) as: *West Cascades Ecoregion/Shrub and Grassland Type/Blue wild rye or Roemer's fescue grass bald communities*. The area consists of a mosaic of open grasslands, young-growth forest and old-growth forest. The grassland balds are surrounded by old-growth *Pseudotsuga menziesii*/*Tsuga heterophylla* (Douglas-fir/western hemlock) forest. The site is recognized for the considerable diversity of plant species

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that includes both Willamette Valley plants as well as plants more often found in the montane zone of the Cascade Range. There is also several plant species present at the site that are normally found east of the Cascade Range.

Three primary communities are found within the ACEC/RNA. Within each of these communities, there are a number of plant associations:

- Grasslands occupy the open, south-facing slopes, usually occurring in areas with shallow soils. The grassland community consists of three distinct plant associations: *Elymus glaucus* (blue wild rye) association; *Festuca idahoensis* (Roemer's fescue) association; and *Stipa lemmonii*/*Racomitrium canescens* (Lemmon's needlegrass/moss) associations (Vanderschaff, 1993).
- The forest community is classified as a *Pseudotsuga menziesii*/*Tsuga heterophylla* (Douglas-fir/western hemlock) association with an understory dominated by small *Berberis nervosa* (Cascade Oregon grape), *Gaultheria shallon* (salal), and *Symphoricarpos albus* (snowberry). The forest occurs on the deepest soils within the natural area (Vanderschaff, 1993).
- Stands of *Quercus garryana* (Oregon white oak) can be found around the edges of the grass balds.

Horse Rock Ridge Research Natural Area Guidebook, Supplement 27 (Curtis 2003), provides detailed information on geology, soils, hydrology, vegetation, fauna, research and disturbance history (Refer to Horse Rock Ridge Research Natural Area, Guidebook Supplement 27).

Project history

The Institute for Applied Ecology initiated restoration work at Horse Rock Ridge in 2006. Maps of native plant communities and exotic species occurrences were completed in 2009. Completed maps of all mapped invasive species and plant communities can be found in the Horse Rock Ridge Restoration Plan (Thorpe 2010) and 2010 report (Thorpe and Giles-Johnson 2010). Plots to test the effects of restoration treatments were established in 2008 in mesic and xeric meadow communities. Treatments included seed addition, solarization plus seed addition (mesic meadow only), carbon + seed addition, and control. Final results from this study will be reported in the 2014 final report, however preliminary results indicate that in both the mesic and xeric plots, there was a positive effect of just seed addition, suggesting that **seed limitation may be the strongest factor limiting native plant cover in these meadows**. Interestingly, treatments also appear to have an effect on the survivorship of outplanted individuals into the treatment plots- with higher survivorship in treated plots in both mesic and matrix plots. This information will be valuable as restoration moves forward at the site to increase the effectiveness and success of future outplanting and restoration efforts. Future monitoring of these plots will follow the protocol described in the Horse Rock Ridge Restoration Plan, and will inform restoration efforts at the site.

Additional restoration treatments include weed control, as well as seeding and planting of native species. These activities have been undertaken under the guidance of the Horse Rock Ridge Restoration Plan and are summarized in this report.

WEED CONTROL

Invasive plants pose a direct threat to the sensitive plants and plant communities at Horse Rock Ridge. An important factor for which Horse Rock Ridge was designated an ACEC/RNA includes its plant community attributes (e.g. diversity of native species and coexistence of species typical of the Willamette Valley, Cascade montane zone, and eastern Oregon), so the control and elimination of invasive/noxious weed infestations is a priority (Sawtelle 2006).

There are several challenges to invasive weed control at Horse Rock Ridge, including the relatively continuous distribution and high cover of several invasive species, (Appendix A) a high proportion of weed seeds to native seeds in the seed bank, thin and fragile soils, the presence of native species in even the most degraded habitats, the lack of large quantities of genetically appropriate native seed, the limited use of chemical herbicides (due to agency restrictions), and cost. A detailed description of weedy species, as well as maps of the distribution of weedy species can be found in Giles-Johnson 2010. Exotic species that form part of the matrix community including *Bromus rigidus*, *Cynosurus echinatus*, *Vulpia bromoides*, *Aira caryophyllea* and *Hypochaeris radicata* are present throughout Horse Rock Ridge and currently are not the focus of control methods (though in scattered patches of otherwise high quality habitat, these species have been removed).

Invasive weeds occurring in small patches

Several invasive species, including *Cirsium* ssp., *Geranium dissectum*, *Sonchus asper*, *Rubus* spp. and *Tragopogon dubius* were found only as scattered individuals or in small patches. After we identified and mapped these individuals, we either manually removed them by pulling and/or grubbing or removed all of their aboveground biomass using loppers in both the spring and fall ([Table 1](#)). Plant material was left on site when appropriate; otherwise, it was bagged and carried off site for disposal. We revisited these sites through 2013 to repeat treatments as necessary.

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Control of more ubiquitous invasive species including, *Holcus lanatus*, *Hypochaeris radicata*, *Rumex acetosella*, *Hypericum perforatum* and *Leucanthemum vulgare* were focused in; 1) areas of otherwise high quality, 2) in areas that were outplanted with bulbs, seeds or plugs, and 3) in areas where the offending species was found in isolated patches (to decrease the spread of weed seed). Additionally, a persistent patch of *Rumex crispus* in an ephemeral pool has been pulled annually, and cover of the invasive species has decreased. A summary of weedy species treated can be found in [Table 1](#),

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TABLE 1. INVASIVE SPECIES MAPPED IN THE MEADOW COMMUNITIES AT HORSE ROCK RIDGE AND CONTROL EFFORTS IN 2008-2013

Species	Distribution	Treatment
<i>Aira caryophylla</i>	Occurs throughout the mesic and xeric communities, occasionally in dense patches.	None ¹
<i>Alliaria petiolata</i>	One plant	Hand-pulled 2008; was not found in 2009-2013
<i>Bromus diandrus</i> (<i>B. rigidus</i>)	Typically occurs in relatively dense patches.	None ¹
<i>Bromus hordeaceus</i>	Occurs throughout the mesic and xeric communities, occasionally in dense patches.	None ¹
<i>Cirsium vulgare</i>	Infrequent individuals and small to medium patches.	Hand-pulled 2008, 2009; none found in 2010 or 2013.
<i>Dactylis glomerata</i>	Infrequent individuals and small patches underneath trees in meadows	None ¹
<i>Digitalis purpurea</i>	Infrequent patches up to approximately 100 plants, most abundant in organic soils around decomposed logs.	Hand-pulled 2008, 2009, 2010, 2011, 2012 ¹
<i>Geranium dissectum</i>	3 small patches	Hand-pulled 2008; was not found in 2009
<i>Holcus lanatus</i>	Distributed throughout as individuals and patches, higher density in mesic areas.	None ¹

<i>Hypochaeris radicata</i>	Common matrix weed species.	Hand-pulled individuals 2008-2013, with focus in medium to high-quality patches, particularly in areas that were outplanted with native grass and forb species in the fall of 2012 and 2013.
<i>Hypericum perforatum</i>	Relatively common as individuals and small patches throughout meadow complex.	Hand-pulled certain areas in 2010, 2011, 2012, 2013 ¹
<i>Leucanthemum vulgare</i>	Locally common in mesic meadows.	Hand-pulled certain areas in 2010, 2012 and 2013 ¹
<i>Rubus armeniacus</i>	Found in areas with greater soil development adjacent to forest edges and around decomposed logs.	Clipped back in one area in 2008 and 2010. Additional plants clipped and root crowns removed in 2012 and 2013.
<i>Rubus laciniatus</i>	Found in areas with greater soil development adjacent to forest edges.	None ¹
<i>Rumex acetosella</i>	Infrequent small patches	Hand-pulled 2008, 2009, 2010
<i>Rumex crispus</i>	Infrequent individuals and small patches	Hand-pulled 2008-2013
<i>Senecio jacobaea</i>	Infrequent individuals and small patches throughout HRR	Hand-pulled 2008-2013—most plants had bio-control caterpillar on them in 2010.
<i>Sonchus asper</i>	Several small patches (fewer than 10 individuals each)	Hand-pulled 2008, 2009, 2011, 2012. No plants were noted in 2013.
<i>Taeniatherum caput-medusae</i>	Common on mesic mounds within xeric areas.	
<i>Tragopogon dubius</i>	Handful of small patches	Hand-pulled 2008, 2010, 2011, 2012, 2013

<i>Vicia sativa</i>	One small patch (2008); additional patch was located in 2011 nearby and pulled	Hand-pulled 2008; was not found in 2009, some pulled in 2011
<i>Vulpia bromoides</i>	Occurs throughout the mesic and xeric communities, occasionally in dense patches.	Hand-pulled in areas outplanted in 2013.

¹Treatment on these species is not feasible given available resources, however scattered individuals were occasionally pulled.

Horse Rock Ridge Assessment, Seed Collection, and Restoration

TABLE 2. CURRENT SEED INVENTORY OF NATIVE PLANT SPECIES COLLECTED AT HORSE ROCK RIDGE FROM 2008-2013. CLEAN GRAMS REPRESENT INVENTORY REMAINING AS OF 2013. SOME COLLECTIONS HAVE BEEN USED FOR SEEDING AND GROWOUT AND ARE LISTED ELSEWHERE. THE NUMBER OF SEEDS FOR SOME SPECIES COULD NOT BE ESTIMATED SO ARE LABELED UNKNOWN ("UNK"). + INDICATES SPECIES IN GROWOUT FOR OUTPLANTING IN 2014. * INDICATES SPECIES WHOSE COLLECTIONS HAVE BEEN DEPLETED IN RESTORATION AND GROWOUT ACTIVITIES.

Scientific Name	Family	Form	Collection date	Clean grams	# seeds (rough)
<i>Agoseris grandiflora</i>	Asteraceae	Forb	8/6-7/08, 7/23-24/08, 8/1/11, 7/25/13	13.05	7,873
<i>Allium acuminatum</i> *	Liliaceae	Forb	8/6/08		
<i>Allium amplexans</i>	Liliaceae	Forb	8/6-8/08	0.69	535
<i>Allium crenulatum</i>	Liliaceae	Forb	8/6-7/08, 7/23-24/08	1.92	1,482
<i>Balsamorhiza deltoidea</i>	Asteraceae	Forb	7/11/08, 7/23-24/08, 7/5/12, 8/14-15/12	26.05	247
<i>Brodiaea hyacinthina</i>	Liliaceae	Forb	8/6-7/08	3.1	unk.
<i>Bromus carinatus</i> ⁺	Poaceae	Grass	7/23-24/08, 7/23/2009, 8/14-15/12	497.6	77,888
<i>Calochortus tolmiei</i>	Liliaceae	Forb	8/6-7/08	1.4	1,193
<i>Camassia leichtlinii</i>	Liliaceae	Forb	8/6-7/08	4.9	1,572
<i>Clarkia gracilis</i>	Onagraceae	Forb	8/6-7/08, 7/23-24/08	4.7	11,812
<i>Clarkia</i> spp.	Onagraceae	Forb	7/23/09, 8/12/09	2.03	5,102
<i>Danthonia californica</i> ⁺	Poaceae	Grass	7/23-24/08, 8/6-7/08, 7/23/09, 8/12/09, 8/14-15/12, 7/9/13, 7/25/13	107.0	33,025

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Scientific Name	Family	Form	Collection date	Clean grams	# seeds (rough)
<i>Daucus pusillus</i> ⁺	Apiaceae	Forb	8/6-7/08, 7/23/2009, 7/5/12, 8/14-15/12	56.4	55,705
<i>Delphinium menziesii</i> var. <i>pyramidale</i> ^{**}	Ranunculaceae	Forb	8/6-7/08, 7/23-24/08		
<i>Dodecatheon pulchellum</i> var. <i>pulchellum</i> ⁺	Primulaceae	Forb	8/6-7/08, 7/23-24/08, 8/14-15/12	9.74	7,013
<i>Elymus glaucus</i> ⁺	Poaceae	Grass	8/6-7/08, 7/23/09, 8/12/09, 8/14-15/12, 7/25/13	277.44	73,398
<i>Erigeron compositus</i> var. <i>glabratus</i>	Asteraceae	Forb	7/23-24/08, 7/3/2009, 8/1/11, 7/25/13	7.41	14,703
<i>Eriogonum nudum</i>	Polygonaceae	Forb	8/6-7/08, 7/23-24/08	10.7	1,930
<i>Eriophyllum lanatum</i> ⁺	Asteraceae	Forb	7/23-24/08, 9/2-3/08, 7/3/09, 7/23/09, 8/12/09, 8/1/11, 7/5/12, 8/14-15/12, 7/25/13	175.24	451,648
<i>Erythronium</i> spp.	Liliaceae	Forb	8/6-7/08	0.9	153
<i>Festuca idahoensis</i> ⁺	Poaceae	Grass	8/6-7/08, 7/23-24/08, 7/23/09, 8/12/09, 8/1/2011, 8/14-15/12	479.57	528,636
<i>Gilia capitata</i> ssp. <i>capitata</i>	Polemoniaceae	Forb	8/6-7/08	1.2	2,669
<i>Koeleria cristata</i> ⁺	Poaceae	Grass	8/6-7/08, 9/2-3/08, 8/12/2009, 8/14-15/12, 7/25/13	157.59	804,293

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Scientific Name	Family	Form	Collection date	Clean grams	# seeds (rough)
<i>Lomatium utriculatum</i> ⁺	Apiaceae	Forb	8/6-7/08, 7/23-24/08, 7/3/2009, 8/1/11, 7/5/12, 8/14-15/12, 7/25/13	39.32	24,078
<i>Madia gracilis</i> ⁺	Asteraceae	Forb	7/23-24/08, 7/3/2009, 7/25/13	49.21	79,197
<i>Microsteris gracilis</i>	Polemoniaceae	Forb	7/23-24/08, 7/3/2009, 8/1/11	0.67	559
<i>Mimulus guttatus</i>	Scrophulariaceae	Forb	7/23-24/08, 7/3/2009, 8/1/11	11.32	Unk.
<i>Orthocarpus hispidus</i>	Scrophulariaceae	Forb	8/6-7/08, 7/23-24/08, 7/3/2009, 8/1/11	10.26	84,819
<i>Perideridia gairdneri</i> ssp. <i>borealis</i> ⁺	Apiaceae	Forb	8/6-7/08	11.06	11,521
<i>Plectritis congesta</i>	Valerianaceae	Forb	8/6-7/08, 7/23-24/08	5.7	14,988
<i>Poa scabrella</i> ⁺	Poaceae	Grass	8/6-7/08, 7/23-24/08, 9/2-3/08, 7/23/2009	68.21	157,439
<i>Potentilla glandulosa</i> [*]	Rosaceae	Forb	8/6-7/08, 9/2-3/08	n/a	n/a
<i>Saxifraga</i> cf. <i>integrifolia</i>	Saxifragaceae	Forb	9/2-3/08	1.1	unk.
<i>Sedum spathulifolium</i>	Crassulaceae	Forb	9/2-9/3	1.28	unk.
<i>Stipa lemmonii</i> ⁺	Poaceae	Grass	7/23-24/08, 7/3/09, 7/23/09	37.95	8,925
<i>Trifolium microcephalum</i>	Fabaceae	Forb	8/6-7/08, 7/23-24/08, 7/3/2009	9.9	4,365
<i>Trifolium triternatum</i>	Fabaceae	Forb	7/23-24/08, 7/3/09,	28.73	20,251

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Scientific Name	Family	Form	Collection date	Clean grams	# seeds (rough)
			7/23/09		
<i>Zigadenus venenosus</i> var. <i>venenosus</i>	Liliaceae	Forb	8/6-7/08	4.8	3,175

SEED COLLECTION AND GROW-OUT

Seed Collection and Distribution

We collected seed from native plant species in 2008, 2009, 2010, 2012 and 2013 for restoration in 2008 – 2014 (Table 2). Species were chosen to be representative of the flora in the mesic and xeric communities, with an emphasis on native grasses and “aggressive” forb species (e.g. *Madia gracilis*, *Eriophyllum lanatum*, and *Clarkia* spp.). As native grasses are morphologically similar to invasive grasses, they may offer higher resistance to reinvasion by exotic grasses compared to forbs. We selected aggressive native forbs that typically germinate quickly, grow quickly, and produce copious seeds. Seeds were cleaned either by hand or using the cleaning equipment at the USDA Natural Resources Conservation Service Native Plants Material Center located in Corvallis, Oregon.

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The total number of seeds collected was estimated by multiplying the weight of the collected seeds by seed per pound data used by Beauty Beyond Belief (<http://www.bbbseed.com/>) and Heritage Seedlings Inc. (<http://www.heritageseedlings.com/native.htm>). As we do not know the purity of our collections, these numbers should be assumed to only be rough estimates.

Annually since 2008, seeds of 8 and 10 species have been collected for the Seeds of Success program (with the exception of 2010). Seed collection to support restoration continued into 2013. A relatively small amount of seed was used in the experimental trials established in 2008, for growout by Trillium Nursery and IAE through 2013. Additionally, seed has been collected and immediately distributed on site during invasive species removal and control efforts.

Propagation and Outplanting

As described above, seed limitation presents one of the greatest limitations to increasing native plant communities at the site. Plant establishment is also limited by the harsh environmental conditions at the site; most areas are characterized by shallow soils and steep slopes that limit water and nutrient retention. Due to the large area needing restoration at Horse Rock Ridge and the relatively low amount of seeds available for restoration, we are focusing our efforts on creating ‘diversity islands’ that extend or connect medium and high quality patches of native plant species. Once established, these areas should provide seed to naturally expand native patches. As this work continues to be successful we have begun to transition our efforts in areas of deeper soils and lower quality habitat, with a focus on replacing non-native species with propagules of native forbs and grasses.

Late in 2009, a selection of bulb species were outplanted into a deep outdoor bed for propagation. These bulbs were harvested and subsequently outplanted in the fall of 2012. A list of species grown and the quantity of bulbs harvested (and planted) can be found in Table 4, Figure 1.

In the fall of 2010 (4) and 2011 (6) a total of ten seed islands were established using plants grown by Trillium and IAE staff from seeds collected on site (Figure 1, Table 6, Appendix C). Two of the four areas outplanted included the experimental treatment plots (including the control plots). Two additional areas were selected in 2010 as seed islands due to the proximity of medium to high quality habitat. Six additional seed islands were created in 2011 with focus on the central meadow (Figure 1, Table 6).

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The seed islands were planted in a checkerboard grid with 1 m x 1 m squares. The one meter square was divided into 25 separate 20 cm x 20 cm sections; a plant was placed in the middle of each section for a total of 25 plants per 1 m². Plants were randomly selected to fill the grid and a combination of both forbs and grasses were planted. Outplanted species in 2010/2011 include: *Danthonia californica*, *Elymus glaucus*, *Koeleria cristata*, *Stipa lemmoni*, *Balsamorhiza deltoidea*, *Erigeron compositus*, *Eriophyllum lanatum*, *Mimulus guttatus*, and *Potentilla glandulosa*.

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TABLE 3. TIMELINE OF RESTORATION ACTIVITIES AT HORSE ROCK RIDGE FROM 2008-2014.

		2008	2009	2010	2011	2012	2013	2014
Seed Collection	Collection	x	x		x	x	x	(x)
	Number of species, grams							
	Distribution of select seed			x	x	x*	x*	(x)*
Outplanting	Number of areas outplanted			4	6	9	20	~20
	Number of bulbs/plugs outplanted			2,000	~1,200	2,357	2,185	~3,000
	Description			4 seed islands, experimental plots + 2 other islands	6 islands	Bulbs outplanted	Grass and forb species	plants currently in production
Growout	Trillium Nursery	x	x					
	FSL Beds (by IAE)		x	x	x			
	OSU Greenhouse (by IAE)			x	x	x	x	x
Management Trials								
	Ongoing in both mesic and xeric meadows including, solarization, carbon addition and seed addition. Qualitative and quantitative monitoring of all restoration activities also have occurred annually.	x	x	x	x	x	x	x

*during invasive species control efforts, native seeds from nearby species were often distributed over the resulting disturbed ground.

TABLE 4. BULB SPECIES OUTPLANTED AT HORSE ROCK RIDGE IN THE FALL OF 2012. BULBS WERE GROWN FROM SEED COLLECTED ON SITE.

Species	Size Class	Number of bulbs outplanted in 2012
<i>Allium acuminatum</i>		2
<i>Allium crenulatum</i>		53
<i>Allium amplexans</i>		174
<i>Brodiaea hyacintha</i>		79
<i>Camassia leichtlinii</i>	< 5 cm	109
	5-8 cm	98
	8-12 cm	33
	>12 cm	5
<i>Calochortus tolmiei</i>		2
<i>Zigadenus venenosus</i>		1802
Total		2357

In the winter of 2012, fourteen grass and forb species were selected for growout and were outplanted in the fall of 2013 (Table 5). In 2012, bulbs of the following species were incorporated into the seed islands: *Allium amplexans*, *Allium acuminatum*, *Allium crenulatum*, *Brodiaea hyacinthina*, *Calochortus tolmiei*, *Camassia leichtlinii*, *Erythronium* sp., and *Zigadenus venenosus* (Table 4). A total of nine areas were outplanted with the seven bulb species grown by IAE. Four areas were outplanted with camas only and five areas received a mix of all bulb species. In the nine areas outplanted, 22 1m² grids were outplanted with mix of bulb species, and an additional 20m² were outplanted with camas alone.

Areas to receive only camas were selected to have deeper soils and medium to high quality plant communities. Some camas bulbs had reached considerable size (more than 6" long with bulbs 1"-3" in diameter) at the time of outplanting. In the remaining four outplanted areas, one to five bulbs were outplanted into each grid 20cm x 20cm grid square such that each square meter outplanted has anywhere from 25-125 bulbs. Maps of the plot locations can be found in Figure 1.

In 2013, twenty additional seed islands were created with eleven native species (Table 5). These twenty islands were selected to be in areas of medium quality habitat. When outplanting weedy species, most commonly *Hypochaeris radicata* and *Holcus lanatus*, were removed and the empty hole filled with a native grass or forb. At least 2,185 plants were outplanted, in 20 islands covering a total of approximately 90m² of habitat (Figure 1).

TABLE 5. QUANTITY AND SPECIES OUTPLANTED IN THE FALL OF 2013.

Species	Growth Form	Approx # of plants
<i>Bromus carinatus</i>	Graminoid	180
<i>Danthonia californica</i>	Graminoid	180
<i>Daucus pusillus</i>	Forb	110
<i>Elymus glaucus</i>	Graminoid	180
<i>Eriophyllum lanatum</i>	Forb	770
<i>Festuca idahoensis</i>	Graminoid	180
<i>Koeleria cristata</i>	Graminoid	180
<i>Lomatium utriculatum</i>	Forb	45
<i>Madia sp.</i>	Forb	140
<i>Poa scabrella</i>	Graminoid	180
<i>Stipa lemmonii</i>	Graminoid	40
TOTAL:		2,185

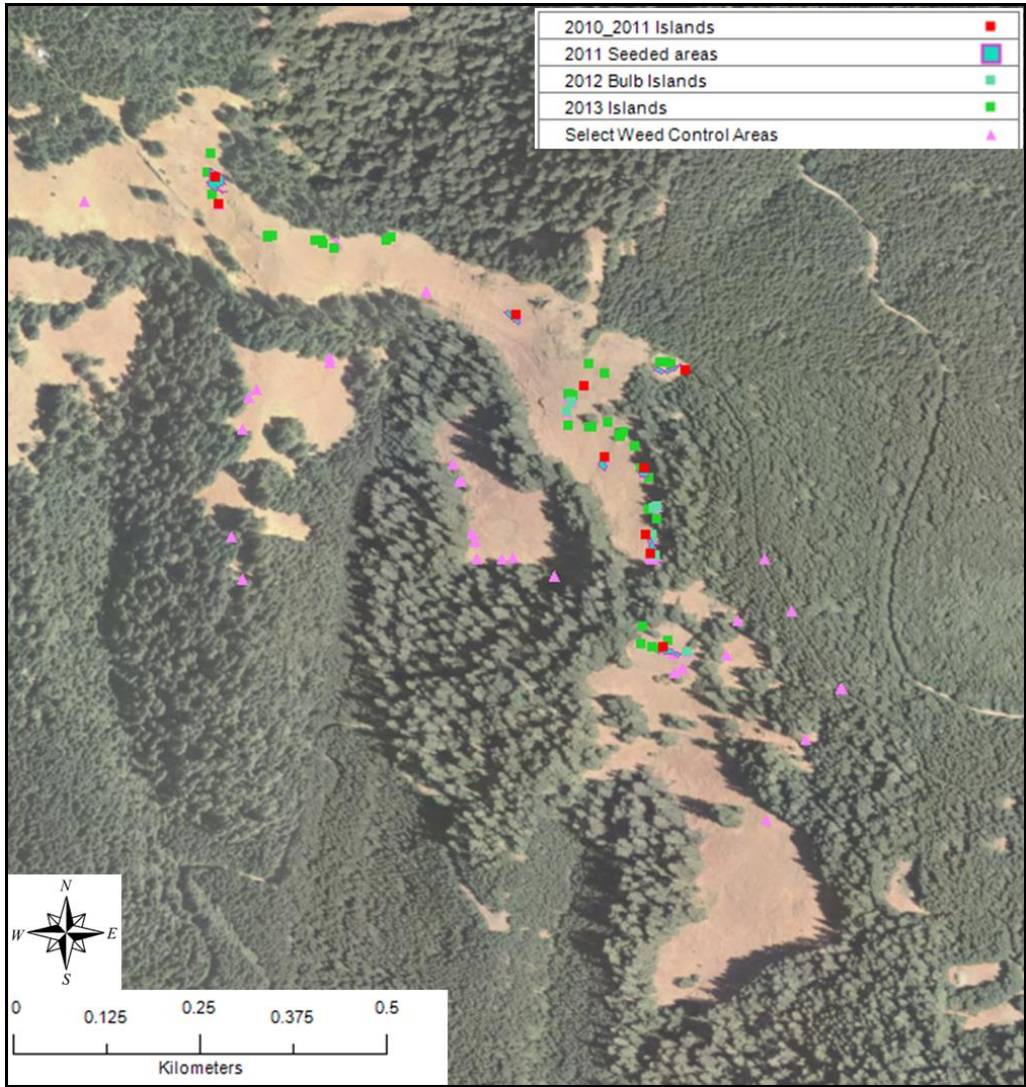


FIGURE 1. LOCATION OF SELECT RESTORATION AND OUTPLANTINGS AT HORSE ROCK RIDGE FROM 2010-2013. PURPLE TRIANGLES INDICATE SELECT AREAS OF WEED CONTROL, RED SQUARES 2010 AND 2011 OUTPLANTINGS, TEAL SQUARES AREAS OUTPLANTED WITH BULBS IN 2012 AND GREEN SQUARES INDICATE AREAS OUTPLANTED WITH GRASS AND FORB SPECIES IN 2013.

TABLE 6. COORDINATES OF SEED ISLANDS CREATED IN 2010 AND 2011 (NAD83, UTM10N). LOCATION OF BULB AND SEED ISLANDS OUTPLANTED IN 2012 AND 2013 CAN BE FOUND IN FIGURE 1.

Seed Island Number	Seed Island Name	Latitude	Longitude	Northing	Easting
1	Mesic (LEVU) Meadow Treatment Plots	44.297050	-122.873330	4904874	510106
2	Xeric Treatment Plots	44.296864	-122.875033	4904853	509970
3	2010 Mesic South	44.295874	-122.874018	4904743	510051
4	2010 Xeric South	44.293724	-122.873703	4904504	510077
5	Mesic South 3	44.294837	-122.873903	4904628	510061
6	Mesic South 2	44.295069	-122.873977	4904653	510055
7	Mesic South 1	44.296017	-122.874691	4904759	509998
8	Xeric South	44.297727	-122.876153	4904948	509881
9	Dike Mesic	44.299059	-122.881156	4905096	509481
10	Dike Xeric	44.299397	-122.881191	4905133	509479

Results

TREATMENT EXPERIMENT IN MESIC AND MATRIX COMMUNITIES

Interim results indicate that in the mesic meadows all treatments resulted in increased cover of native grasses and decreases in invasive forbs over controls. Interim results for the matrix plots indicate that seed addition is the most effective treatment at increasing native graminoid cover, however effects on native and invasive forb species is varied. Detailed results comparing pre and post treatment community data in experimental treatment plots from 2008-2014 will be available in the 2014 Horse Report.

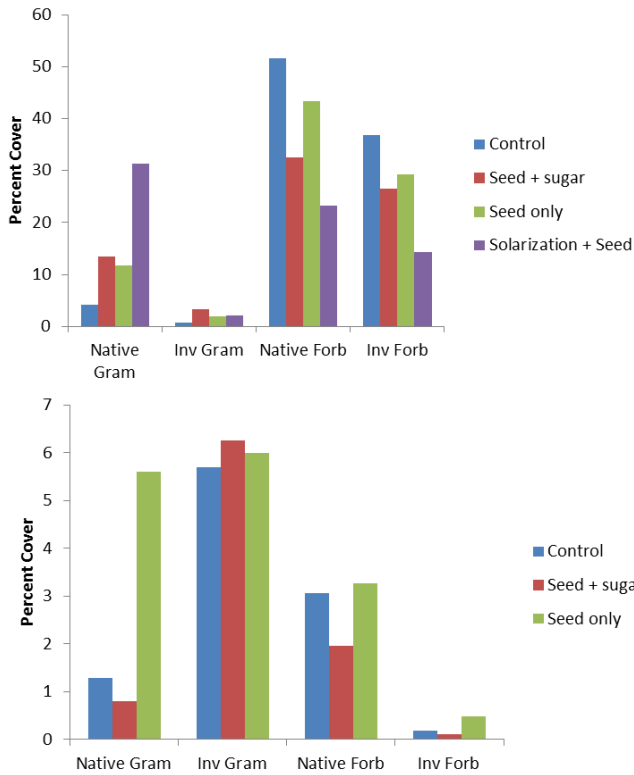


FIGURE 2. PRELIMINARY RESULTS FROM EXPERIMENTAL MANAGEMENT TREATMENTS ON PLANT COMMUNITY COMPOSITION AT HORSE ROCK RIDGE. TREATMENTS WERE INITIATED IN 2008, FINAL MONITORING AND ANALYSIS WILL BE REPORTED IN THE 2014 REPORT.

OUTPLANTING AND SEEDING

During qualitative monitoring in 2012 and 2013 all species seeded were noted germinating and there was increased cover of native species in seeded areas. At the time of monitoring in 2013, increased cover of bulb species was noted in areas that had received bulb outplantings in 2012. Many of the bulbs outplanted in 2012 were predicted to be large enough to produce flowers in their first year and likely contributed to the seed bank in 2013.

From 2010-2013 IAE has planted approximately 5,385 plugs of native graminoids and forbs in both mesic and xeric areas (as well as 2000+ bulbs). Survivorship of plants outplanted in 2010 in both seed islands and the mesic experimental plots was ~69% one year after outplanting. As would be expected survivorship into 2013 is lower, however the range of survivorship for individuals species is 0%-85%. (see discussion below, Figure 2, Figure 3).

The discussion below treats the survivorship of plants outplanted in both the mesic and matrix 'control' experimental treatment plots. These can then be used as a baseline to gauge success of outplantings in other locations on site as well as guide appropriate selection of plant materials. Surviving plants in both mesic and matrix plots are generally thriving, increasing cover of native species and contributing to the native seed bank on the site. With the exception of *Balsamorhiza deltoidea* flowering (or fruiting) individuals of each outplanted species were noted in 2013.

In the mesic treatment plots survivorship from 2010-2013 is 44% (21% in control plots) (with individual species ranging in survivorship from 0-85% (5-43% in control)).

In matrix (dry) islands, survivorship 4 years post-outplanting was 10% with some species as high as 25%. Though survivorship is lower in the harsh(er) and shallow soils of the matrix community, the surviving plants were clearly contributing to the seedbank, and will provide valuable seed addition into the future. As previous work has shown that seed limitation is one of the most important limiting factors at the site, outplanting of mature plugs add cover as well as contributes to the native seed bank.

In 2012 and 2013, the plots were monitored using the moderate monitoring effort protocol described in the Horse Rock Ridge Restoration Plan for both the presence or absence of outplanted individuals as well as for percent cover of native and invasive species. Analysis in 2014 will include an evaluation of the effects of treatment on survivorship of outplanted species.

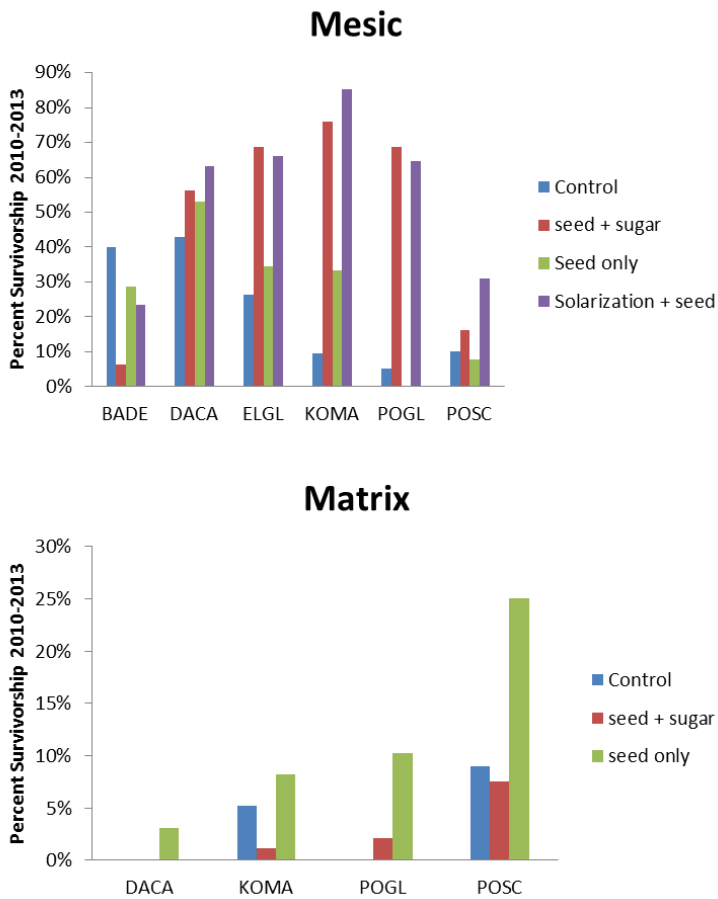


FIGURE 3. PERCENT SURVIVORSHIP BY SPECIES IN THE MATRIX AND MESIC EXPERIMENTAL PLOTS. DETAILED ANALYSIS WILL BE INCLUDED IN THE 2014 REPORT.

Future seeding and planting

The current seed inventory will be used for growout and seeding efforts for restoration at the site. Results from experimental treatments plots has shown that management (solarization, carbon addition) + seed addition results in increased cover of native species. Outplanting efforts into the treatment plots have shown that these management treatments also increase survivorship of native graminoid and forb species. It is recommended that future management include the use these treatments when outplantings (including seed addition, +/- carbon addition, and solarization (where appropriate)).For the species that we have

small amounts of seed or if the species has a more restricted habitat, the seeds will not be mixed, but will be seeded into specially selected suitable habitat. The remaining seeds will be mixed and seeded in areas adjacent to and between seed islands and nearby high-quality habitat.

TABLE 7. BRIEF DESCRIPTION OF THE MULTI-YEAR RESTORATION EFFORT AT HORSE ROCK RIDGE ACEC/RNA.

Phase 1. Site assessment and preparation for large-scale restoration.		
Action	Year	Status
Map and describe native plant communities	2007-2009	Complete
Map important weed species	2007-2009	Complete
Map special habitats	2007-2009	Complete
Conduct experimental treatments to guide future restoration efforts	2007-2010	Complete; continued qualitative monitoring
Identify priority species for restoration	2008-2009	Complete
Collect seed for plug grow-out and seeding in control areas	2008-2009	Complete
Place select species in plug grow-out	2009-2014	Select graminoids, forbs, and Liliaceae spp. to grow-out through fall 2013
Develop Restoration Plan	2006 – 2009	Complete

Phase 2. Large-scale restoration.		
Action	Year	Comments
Assess threats from native (e.g. <i>Rubus ursinus</i>) and invasive shrubs (e.g. <i>Crataegus monogyna</i>); control as necessary	2010	The shallow soils at Horse Rock Ridge generally inhibit encroachment by shrubs and trees. Established shrubs were mapped (Thorpe 2010) and have been the focus of control efforts (Error! Not a valid result for table.).
Remove high-priority invasive weeds	2010-2014	Invasive species occurring as individuals and/or small patches will be removed by hand-pulling, weed-whacking, grubbing, and/or herbicides (Error! Not a valid result for table.).
Seed and plant native plant species	2010-2014	Native plants will be seeded and/or planted into experimental plots, medium-quality native patches, and areas that connect high quality native patches. (See Table 3 for details on outplanting and seeding efforts.)
Monitor effectiveness of previous activities	2009-2014	

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pp.<http://appliedeco.org/reports/Horse%20Rock%20Ridge%20report%202010.pdf>
- USDA Forest Service and USDI Bureau of Land Management. 2001. Record of decision and standards and guidelines for amendments to the survey and manage, protection buffer, and other mitigation measures standards and guidelines. Table 1-1: Species included in survey and manage standards and guidelines and category assignment, Portland, OR.
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<http://www.blm.gov/or/plans/surveyandmanage/SP/VascularPlants/cover.htm>

APPENDIX A. SPECIES FOUND IN MATRIX COMMUNITY

TABLE 8. SPECIES FOUND IN THE MATRIX COMMUNITY AT HORSE ROCK RIDGE LISTED IN ORDER OF ABUNDANCE (HIGH TO LOW).

Scientific name	Family	Growth form	U.S. Nativity
<i>Cynosurus echinatus</i>	Poaceae	Grass	Exotic
<i>Trifolium tridentatum</i>	Fabaceae	Forb	Native
<i>Vulpia bromoides</i>	Poaceae	Grass	Exotic
<i>Aira caryophyllea</i>	Poaceae	Grass	Exotic
<i>Hypochaeris radicata</i>	Asteraceae	Forb	Exotic
<i>Eriophyllum lanatum</i>	Asteraceae	Forb	Native
<i>Bromus hordeaceus</i>	Poaceae	Grass	Exotic
<i>Holcus lanatus</i>	Poaceae	Grass	Exotic
<i>Poa scabrella</i>	Poaceae	Grass	Native
<i>Mimulus guttatus</i>	Scrophulariaceae	Forb	Native
<i>Madia gracilis</i>	Asteraceae	Forb	Native
<i>Linum usitatissimum</i>	Linaceae	Forb	Exotic
<i>Hypochaeris glabra</i>	Asteraceae	Forb	Exotic
<i>Lotus micranthus</i>	Fabaceae	Forb	Native
<i>Perideridia gairdneri</i>	Apiaceae	Forb	Native
<i>Castilleja tenuis</i>	Scrophulariaceae	Forb	Native
<i>Githopsis specularioides</i>	Campanulaceae	Forb	Native
<i>Bromus carinatus</i>	Poaceae	Grass	Native
<i>Galium aparine</i>	Rubiaceae	Forb	Native

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<i>Minuartia tenella</i>	Caryophyllaceae	Forb	Native
<i>Daucus pusillus</i>	Apiaceae	Forb	Native
<i>Silene gallica</i>	Caryophyllaceae	Forb	Exotic
<i>Clarkia gracilis</i>	Onagraceae	Forb	Native
<i>Eriogonum nudum</i>	Polygonaceae	Forb	Native
<i>Trifolium microcephalum</i>	Fabaceae	Forb	Native
<i>Cerastium</i> sp.	Caryophyllaceae	Forb	Exotic
<i>Allium</i> sp.	Liliaceae	Forb	Native
<i>Triteleia hyacinthine</i>	Liliaceae	Forb	Native

APPENDIX B. DATASHEET FOR OUTPLANTING OF SEED ISLANDS AND MONITORING OF TREATMENT PLOTS.

Horse Rock Ridge: Grass community treatment & monitoring form (page 1 of 2)

Names

Date:

Instructions: record aerial cover for each group (minimum) and species.

Total ground cover + Total functional groups cover ≥ 100%. Total ground cover + Total species cover ≥ 100%.

Attach a copy of a site map with the area surveyed delineated.

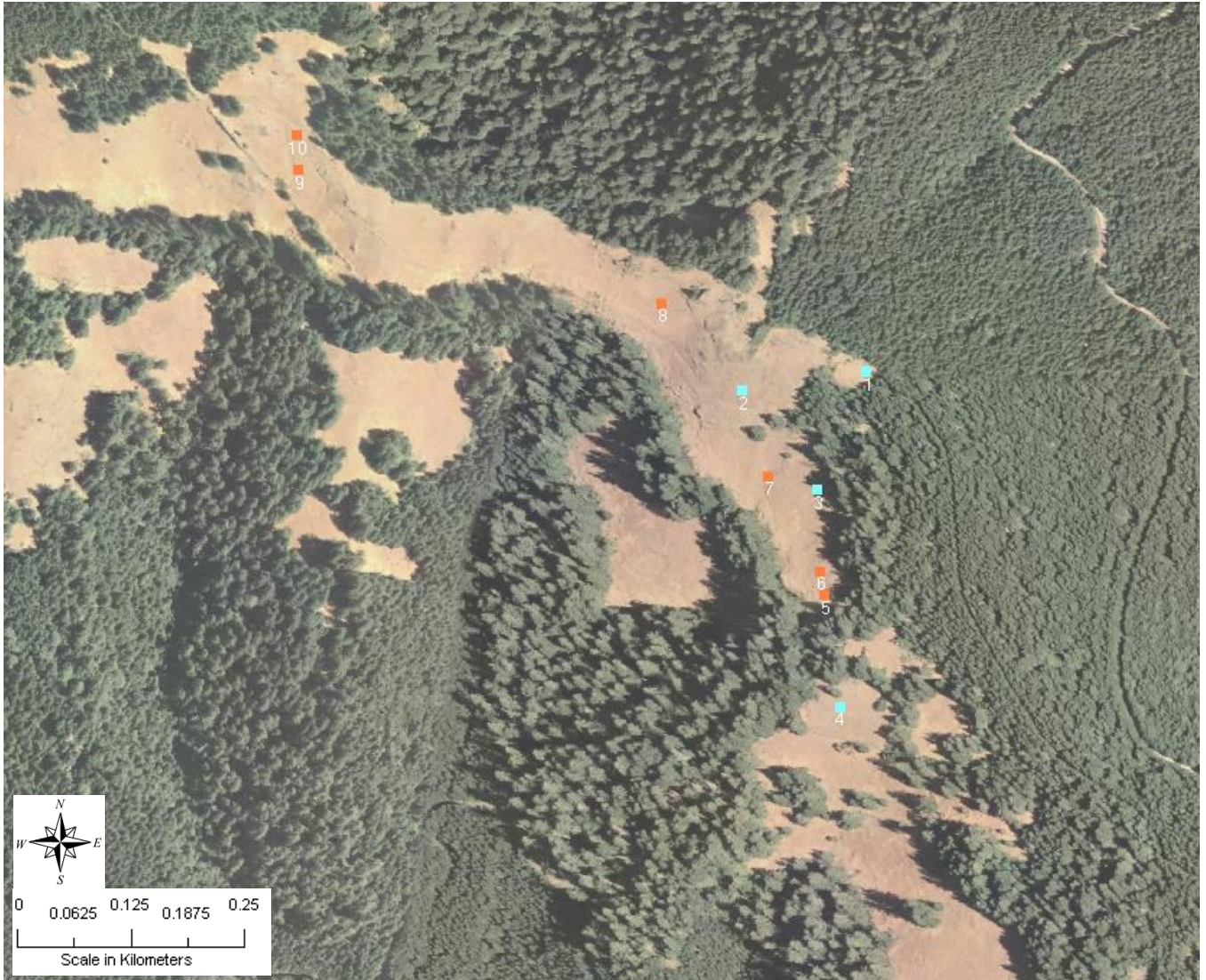
Coordinates					
Treatment description and notes					
<u>Ground cover</u>					
Bare ground					
Rock					
Litter					
Moss					
Lichen					
<u>Functional Groups</u>					
Native trees					
Invasive trees					
Native shrubs					
Invasive shrubs					
Native forbs					
Invasive forbs					
Native graminoids					

Invasive graminoids					
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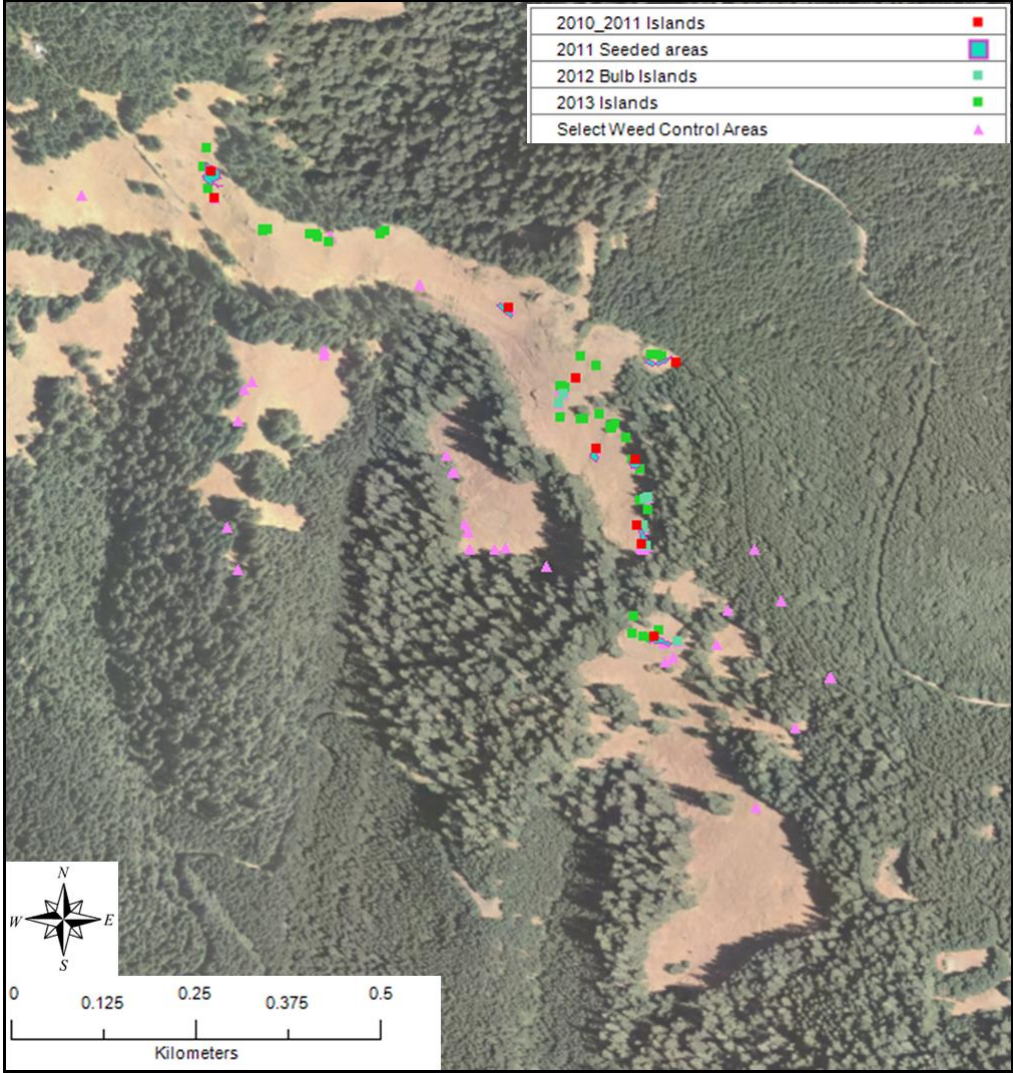
APPENDIX C. DIVERSITY ISLANDS AT HORSE ROCK RIDGE

LOCATION OF ALL SEED ISLANDS AND TREATMENT PLOTS.

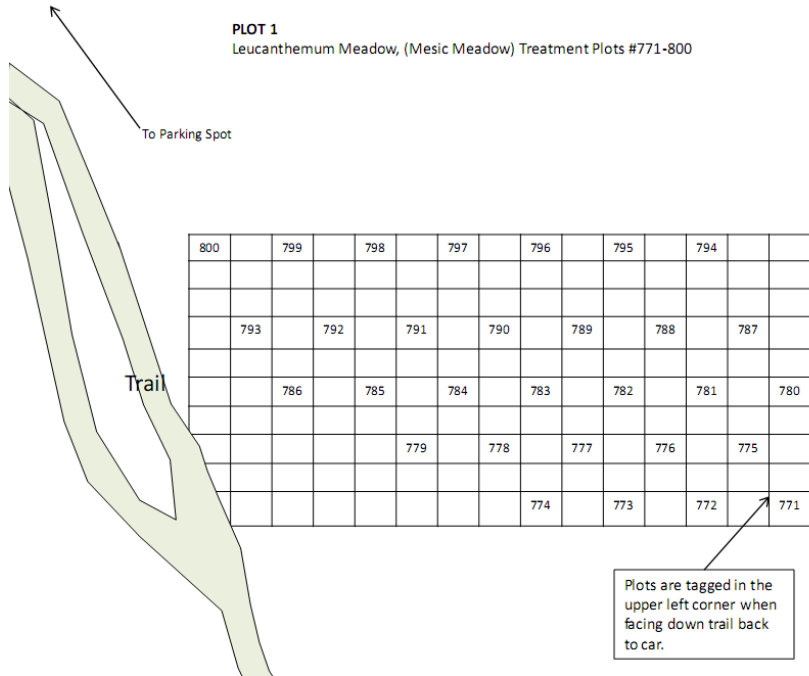
Seed Island	Seed Island Name	Latitude	Longitude	Northing	Easting
1	Mesic (LEVU) Meadow Treatment Plots	44.297050	-	4904874	510106
2	Xeric Treatment Plot	44.296864	-	4904853	509970
3	2010 Mesic South	44.295874	-	4904743	510051
4	2010 Xeric South	44.293724	-	4904504	510077
5	Mesic South 3	44.294837	-	4904628	510061
6	Mesic South 2	44.295069	-	4904653	510055
7	Mesic South 1	44.296017	-	4904759	509998
8	Seric South	44.297727	-	4904948	509881
9	Dike Mesic	44.299059	-	4905096	509481
10	Dike Xeric	44.299397	-	4905133	509479



Location of all treatment plots and seed islands. Blue plots were outplanted in 2010, orange in 2011.



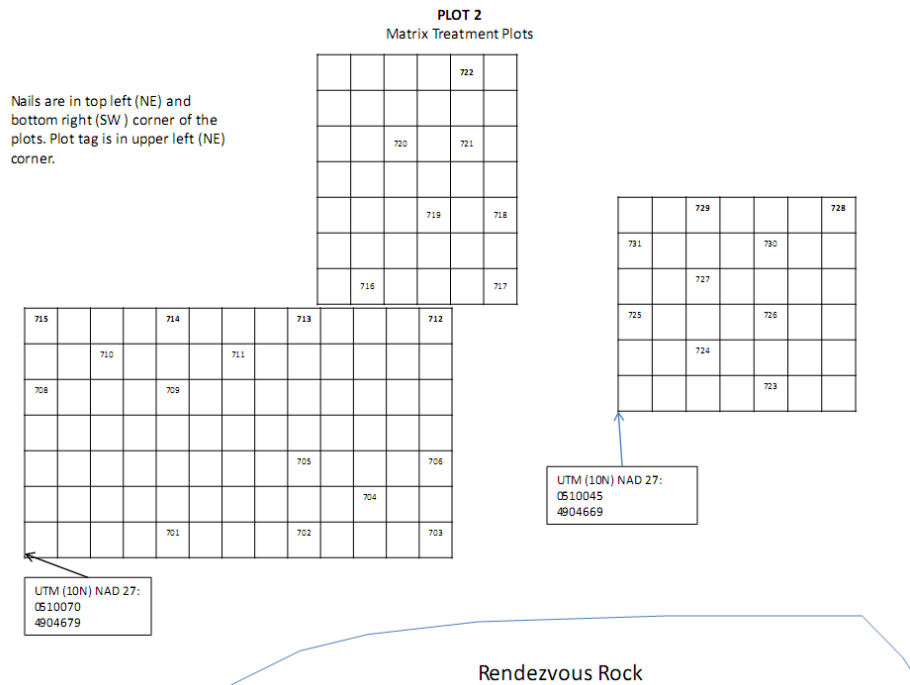
Schematic maps of treatment plots and seed islands follow.



* Plot #798 is askew and not perfectly in line with other plots.

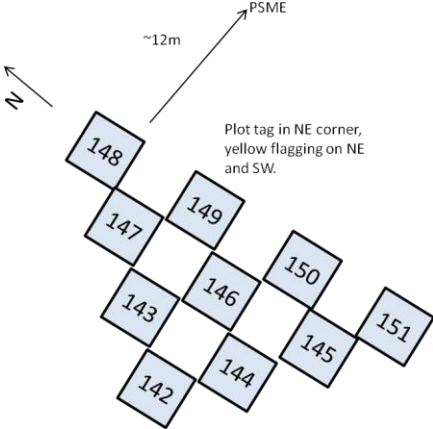
**Plot #789 was renumbered with #589 in 2011.

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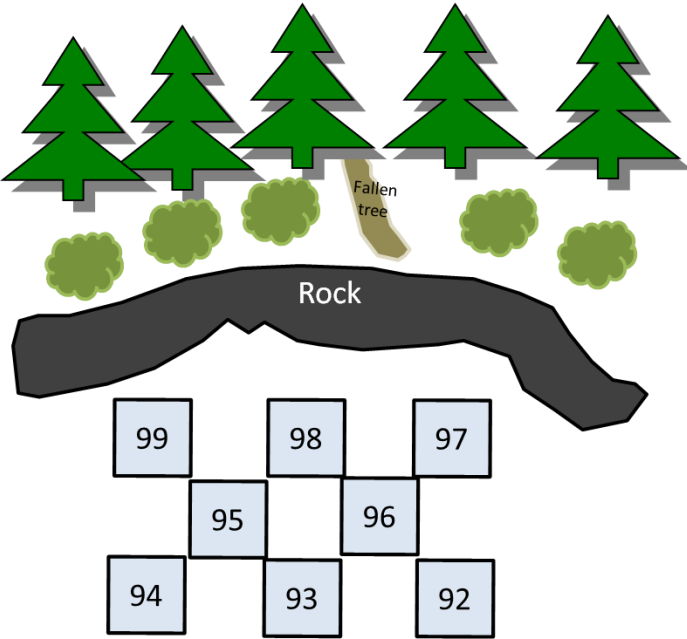


** Tag is missing on plot #704.

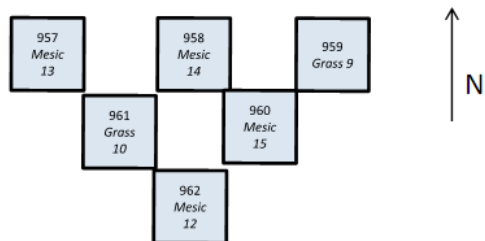
PLOT 3
Mesic Meadow Seed Island:
In South Meadow



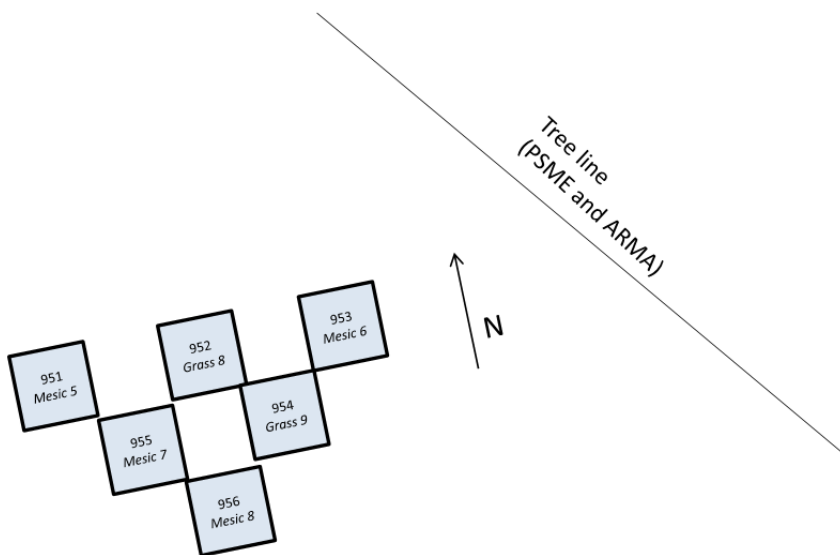
PLOT 4
Matrix (Xeric) Seed Island
In South Meadow



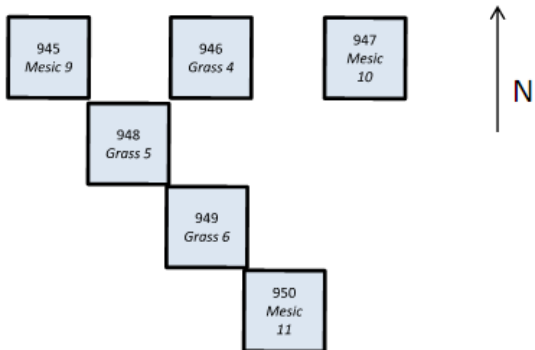
PLOT 5
Mesic Seed Island,
South #3



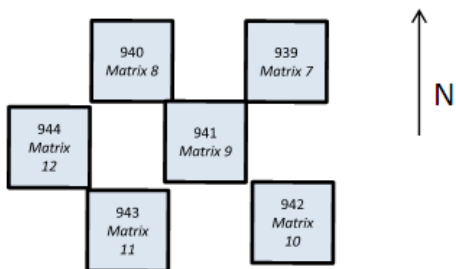
PLOT 6
Mesic Seed Island,
South #2



PLOT 7
Mesic Seed Island,
South #1

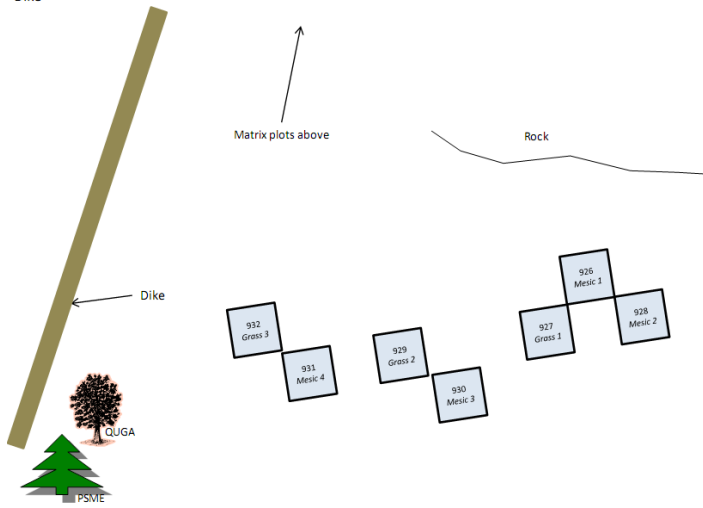


PLOT 8
Matrix Seed Island,
South



Horse Rock Ridge Assessment, Seed Collection, and Restoration

PLOT 9
Mesic Seed Island,
Dike



PLOT 10
Matrix Seed Island,
Dike

