Demography and Management of Willamette Daisy (*Erigeron decumbens*)

2013

Report to the U. S. Fish and Wildlife Service (Phase 2 Final Report, Phase 3 Progress Report)

Report prepared by Denise E. L. Giles-Johnson
Institute for Applied Ecology

Institute for Applied Ecology

PREFACE

This report is the result of an agreement 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. Our aim is to provide a service to public and private agencies and individuals by developing and communicating information on ecosystems, species, and effective management strategies and by conducting research, monitoring, and experiments. IAE offers educational opportunities through 3-4 month internships. Our current activities are concentrated on rare and endangered plants and invasive species.

Questions regarding this report or IAE should be directed to:

Denise Giles-Johnson
Institute for Applied Ecology
PO Box 2855
Corvallis, Oregon 97339-2855

phone: 541-753-3099 ext. 507
fax: 541-753-3098
email: denise@appliedeco.org

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the cooperation provided by the USFWS, particularly Jennifer Thompson. IAE staff in 2013 Michelle Allen, Charlotte Trowbridge, Stacy Moore, and Shell Whittington; and IAE/Native Plant Society of America interns Andrew Heaston, Kelsey Copes-Gerbitz, Tobin Weatherson and ASE intern Eric McDougal. Additional support has been provided by Jock Beall (USFWS, Finley National Wildlife Refuge) and Wes Messinger (USACE Fernridge Natural Area). Matt Melethin (Integrated Resource Management) and Cody Wood assisted with management treatments.

Cover photograph: *Erigeron decumbens* at Finley National Wildlife Refuge

REFERENCE

Giles-Johsnon, D.E.L. 2013. Demography and Management of Willamette daisy. Phase 1 Final Report, Phase 2 Progress Report. Prepared by Institute for Applied Ecology for US Fish and Wildlife Service; Corvallis, Oregon. iii + 34 pp.

TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

INTRODUCTION

Willamette daisy (*Erigeron decumbens;* Figure 1) is listed as an endangered species under the Oregon and federal Endangered Species Acts (ORBIC 2010) Without direct intervention, its prospects for recovery are poor. The majority of populations are small, isolated, and found on unprotected lands. Further, natural recruitment is low due to competition with invasive weeds, altered disturbance regimes, and possible genetic issues (Thorpe and Kaye, *in press*). In the *Recovery Plan for the Prairie Species of Western Oregon and Southwestern Washington* (USFWS 2010), both invasive species and improper prairie management were identified as important threats to Willamette daisy. Although management practices such as mowing, grazing, burning, thatch removal, and selective use of herbicides can be useful techniques to maintain prairie habitats and discourage invasive species (Pfeifer-Meister et al. 2007, Boyer 2008; Stanley et al. 2008; Stanley et al. 2010), applying these treatments in the wrong season and/or with the wrong frequency can have detrimental impacts on native prairie species. Unfortunately, we currently have little information on how Willamette daisy responds to various management activities. ***The goal of this project is to combine careful demographic studies with experimental habitat management treatments in order to provide information on effective management of this species.***

Figure 1. Flowering Willamette daisy planted at Finley National Wildlife Refuge in April 2011.

Management treatments

Mowing and prescribed fire are the two management techniques most commonly used to maintain habitat occupied by Willamette daisy. However, there is little data on the effects of these treatments on birth and death rates of the species. In a five-year study at Oxbow West, we found that compared to control plots, there tended to be fewer, but larger plants in plots that had been mowed every-other-year or burned (Thorpe and Kaye 2007). There also tended to be fewer capitula per plant in the mowed plots, suggesting that management techniques might not always have positive effects on the species. However, active management is required in most prairies to reduce the cover of invasive and woody plant species (Noss et al. 1995, Floberg et al. 2004). The focus of this study is to determine habitat management techniques that will reduce the cover of invasive and woody plant species while maintaining or enhancing the cover of native species, including Willamette daisy.

We will test the effectiveness of mowing, prescribed fire + glyphosate, glyphosate only (Finley only), sheep grazing, grass-specific herbicide [Fusilade™ (Fluazifop)], and carbon addition as habitat management techniques in habitat occupied by Willamette daisy. Thatch removal had originally been identified as a potential treatment; however thatch levels at the sites selected for this project were not sufficient to warrant this treatment. Several of these management techniques have previously been found to be effective in enhancing cover of native prairies species in the Willamette Valley/Puget Sounds/Georgia Basin ecoregion (Kirkpatrick et al. 2006; Pfeifer-Meister et al. 2007; Boyer 2008; Stanley et al. 2008; Stanley et al. 2010).

Conducting these experiments in natural populations of Willamette daisy would provide the best test of how Willamette daisy populations respond to management treatments. However, few populations are large enough to allow for a replicated study and agency regulations limit the scope of treatments that can be applied. Thus, for this study we have introduced populations of Willamette daisy in eight macroplots at six sites to test habitat management treatments at two sites each at Finely National Wildlife Refuge, each with two macro plots (USFWS) and 3 sites at the Fern Ridge Natural Area (ACOE) and one site owned and managed by the City of Eugene.

Demographic monitoring

A second objective of this study is to improve our understanding of Willamette daisy population demography. We will use demographic monitoring to determine the effects of habitat treatments on birth and death rates of Willamette daisy. Monitoring will occur in 2011-2014. In the introduced populations, we will record the size (length, width, and height) and reproductive status of each individual. This protocol was followed to monitor the Willamette daisy population at Oxbow West in the West Eugene Wetlands for eight years (Thorpe and Kaye 2007). Each year, we will also survey the area surrounding previously reproductive individuals to evaluate seedling establishment. All individuals will be mapped and assigned unique numbers in order to track yearly changes in individual characteristics and estimate birth and death rates. We will note the presence or absence of grazing for each individual.

In 2011, we also conducted monitoring at several introduced and natural populations throughout the Willamette Valley. The intent of this project is to determine (1) recruitment of new Willamette daisy individuals into introduced populations, and (2) factors impacting recruitment rates. This research was conducted as a MS thesis by Katie Gallagher, at Oregon State University.

METHODS

Plugs for outplanting were produced in fall 2010 – spring 2011 using seed from two Recovery Zones, Corvallis West (Allen and Allen/Muddy Creek), and Eugene West (Balboa and Oxbow West populations). In September of 2010, seeds were placed in germination trays and then placed into 16 weeks of cold stratification at 6°C. Seeds were checked weekly and misted with distilled water to keep them moist. If any mold was present, damaged seeds were removed and a solution of distilled water and hydrogen peroxide was sprayed on the seeds. The seeds were removed from cold stratification and placed in a room with a 25 ^{o}C day / 15 ^{o}C night temperature cycle and 8 h day / 16 h night lighting cycle one week prior to planting into

conetainers. Plants were planted into conetainers 3.81cm wide and 13.97cm deep in trays of 98 and kept at the OSU West Greenhouse. Pots were filled with Gardner's Gold potting soil and placed in a greenhouse maintained at 21^{o}C during the day and 13^{o}C at night with 14 hour daily artificial light provided by Sun System 3 - 400 HPS bulbs. Pots were watered from the bottom 1-4 times per week as necessary. An 8-8-8 fertilizer was sprayed weekly on the plants and then rinsed off to prevent burnt leaves. At approximately eight weeks, the plants were inoculated with nematodes to prevent fungus gnats from attacking the young plants. One week prior to outplanting, all pots were placed outside to harden-off. This procedure was repeated for plants grown for the 2013 outplanting with little variation.

Outplanting

In April 2011, 900 plants were outplanted at Finley National Wildlife Refuge; 450 each in Field 29 and Field 8 North (Appendix A). Finley National Wildlife Refuge (Finley). Finley is located approximately 16 km south of Corvallis, Oregon, in the Benton West Recovery Zone (USFWS 2010). Historical records indicated that this Refuge once hosted a Willamette daisy population, but the population has not been observed in 20 years. In 2007 and 2008, Willamette daisy was introduced to four sites at Finley, including 174 at Field 29. Plots for this experiment were located approximately 30m from the 2007 and 2008 introductions. Field 29 and Field 8 North were selected because of their relatively low cover of exotic plants, general habitat suitability for Willamette daisy, and ease of access for management. Both sites have been under active restoration and management (including herbicide treatments, mowing, and seeding) by USFWS.

At each site three 14m x 22m blocks were marked with rebar pounded flush with the ground and topped with an orange cap. The three blocks are adjacent, and the NW corner of the 'metablock' was marked with a T-post. Within each block there were six 6m x 6m treatment plots, marked with 8" nails pushed flush with the soil surface and capped with marking whiskers. There is a two meter buffer between each treatment square. Willamette daisy plugs were planted along a 5m x 5m grid in the center of each treatment plot (25 plants per plot).

716 plants were outplanted at Fern Ridge Natural Area, 360 at Applegate and 356 at Kirk NE, in April 2011 (Appendix B).Fern Ridge Natural Area is located approximately 60km south of Corvallis, Oregon in the Eugene West Recovery Zone (USFWS 2010), and is managed by the Army Corps of Engineers (ACOE). Applegate and Kirk East were selected because of habitat suitability for Willamette daisy and ease of access for management. Both sites have been under active restoration and management including mowing and invasive weed removal by the ACOE.

144 plants from the ACOE were used in the outplanting in addition to the plants grown by IAE. Four of these plants and 16 of the plants grown by IAE were planted per plot. Although the plants from the ACOE were smaller, they had robust root structure. At each site, three 14m x 38m blocks were marked with fiberglass poles at each corner. Within each block there were six 6m x 6m treatment plots, marked with 8" nails topped with marking whiskers. Due to low germination and survival of Eugene West plants in the greenhouse, we had to reduce both the number of individuals planted in each plot and the number of treatments. Thus, one of the seven blocks was randomly excluded from planting. In the remaining treatment plots, Willamette daisy plugs were planted along a 5m x 5m grid in the center of each treatment plot, with the exception that one row or column was skipped so that 20 plants were in each square.

Each block also contained a 14m x 14m grazing plot; within this plot, plugs were also planted along a 5m x 5m grid in the center of each treatment plot, with the exception that a one row or column was skipped so that 20 plants were in each square. In the spring 2013, an additional four sites were selected for outplanting. At Finley National Wildlife Refuge, in the Corvallis West Recovery Zone, plots were added adjacent to the existing blocks outplanted in 2011 at Field 8N and Field 29. A total of 450 plants were outplanted at each site in 2013.
In the Eugene West Recovery Zone, two additional sites were selected including Big Spires (ACOE) and Atlantic/Pacific, managed by the City of Eugene; 450 plants were outplanted at each site (a total of 900 plants) (Table 1).

Table 1. Sites outplanted with Willamette daisy in 2011 and 2013.

Recovery Zone	**Land Manager**	**Site name**		**Year outplanted**	**Number outplanted**
Corvallis West	USFWS	Finley	Field 8 N	2011	450
			Field 8 N	2013	450
			Field 29	2011	450
			Field 29	2013	450
Eugene West	ACOE	Kirk East		2011	356
		Applegate		2011	360
		Big Spires		2013	450
	City of Eugene	Atlantic/Pacific		2013	450

Table 2. Management treatments tested in the course of this study.

Treament	Treatment Notes/Motivation
Control	-
Burn + Glyphosate	Previous work has shown that in a short window post-burn dormancy non-native species are green thus a broad spectrum herbicide can be used to target dominantly weedy species.
Glyphosate Only (Corvallis West only)	Glyphosate was applied in a 3% solution in the fall at the same time that the 'burn + glyphosate' treatment occurred.
Grass Specific Herbicide	Fusilade was used in this study and applied at the recommended application rate of 1 oz/acre.
Mowing	Treatment occurred in the fall with mowing to a height of 2-6". Mowing equipment utilized included tractors and weedwhackers.
Carbon Addition	Sucrose addition activates soil microbes which ultimately results in decreased availability of ammonium and nitrate in the soil. Preliminary work by IAE as well as other researchers has shown that these carbon treatments tend to have a greater negative impact on non-native species.
Grazing (Eugene West only)	Up to 60 sheep were grazed for 12-36 hours in the 14m x 14m grazing blocks.
(Thatch removal)	(Thatch was not an issue at the sites selected, thus this treatment was not implemented.)

Treatments

The habitat management treatments tested include; mowing, prescribed fire + glyphosate, glyphosate only (Finley only), sheep grazing (Fern Ridge only), grass-specific herbicide (Fusilade), and carbon addition. Thatch removal had originally been identified as a potential treatment; however thatch levels at the sites selected for this project were not sufficient to warrant this treatment. Several of these management techniques have previously been found to be effective in enhancing cover of native prairies species in the Willamette Valley/Puget Sounds/Georgia Basin ecoregion (Kirkpatrick et al. 2006; Pfeifer-Meister et al. 2007; Boyer 2008; Stanley et al. 2008; Stanley et al. 2010). Community cover was estimated in three $1m^2$ plots immediately prior to and following the grazing treatment.

Mowing

Mowing was performed in September 2011, 2012 and 2013. The sites were evaluated in February 2012, 2013 and 2014 and it was determined that a second mowing treatment was not necessary. At Fern Ridge mowing was performed by ACOE staff with a tractor. At Finley, the plots were mowed with a weedeater. Fall mowing reduces thatch accumulation and cuts back fall-growing grasses. Mowing height was 2-6"; plant material was left on site (Figure 2).

Figure 2. Mow plots at Finley, Field 29 (left) and Fern Ridge, Applegate (right). At both sites mowing occurred in mid-September.

Sheep Grazing (Fern Ridge only)

Sheep grazing occurred in the 14m x 14m treatment plots in October 2012. While most native species are dormant in October, several exotic species are green this time of year, which potentially gives them a competitive advantage the following spring. Approximately 60 sheep were placed in each of the grazing plots until there was no longer suitable forage (12 to 16 hours).

Figure 3. Sheep grazing at Applegate. Sixty sheep were placed in each 14m x 14m grazing plot for 12-36 hours.

Grass-specific Herbicide

A grass-specific herbicide [Fusilade™, (Fluazifop)], was applied in early November at a rate of 28oz./acre to treatment plots at both Fern Ridge and Finley to reduce abundance of exotic grasses.

Figure 4. Glyphosate application to a burned plot at Finley, Field 8 (left) and grass-specific herbicide at Finley, Field 29 (right).

Burning + Glyphosate

Burning at Finley occurred on September 20th, 2011 (Figure 5) and the spray of glyphosate (Aquamaster™) occurred one month post-burn with a concentration of 3%. The sites were evaluated two weeks post-burn and there had not yet been significant resprout of invasive species. At the time of herbicide treatment, one month post-burn, vegetation was dominated by invasive species. Burning (and subsequent spraying) at Applegate and Kirk east occurred in the Fall of 2012, and in 2013 at Big Spires and Atlantic Pacific. Fall burning reduces biomass and thatch accumulation and post-burn glyphosate (a broad-spectrum herbicide) application reduces abundance of broad-leaf weeds. This last treatment was developed based on observations that non-native species resprout more quickly after fire than do most native species.

Figure 5. Burned plot at Finley Field 8.

Glyphosate (Finley only)

A broad-spectrum herbicide treatment was implemented in late fall at the Finley sites in 2011, 2012 and 2013. Because most native plants are dormant at this time this spray is expected to target mostly non-native species. A 3% solution of glyphosate (Aquamaster™) was applied to selected treatment plots.

Carbon Addition

In March 2012 (4 sites) and March 2014 (8 sites), we spread 2 kg of carbon m^{-2} (in the form of sucrose) on selected test plots. Carbon addition limits the amount of soil nutrients available for plant growth (particularly nitrogen and phosphorus) by stimulating microbial activity. Several studies have indicated that native species are more capable of tolerating low nutrient conditions than exotic species (Morgan 1994, Reever Morghan and Seastedt 1999, Alpert and Maron 2000, Blumenthal et al. 2003, Kirkpatrick *et al. unpublished data*).

Survivorship and Vigor Monitoring

Survival and growth of all plants was monitored in June 2011-2013, For each individual, we measured the widest diameter of a plant (the outermost part of an individual, including flowers), the diameter perpendicular to the widest diameter, height, and number of capitula (flower heads). The shape of each plant was assumed to be oval, and the maximum diameter and perpendicular diameter were used to calculate the elliptical crown cover of each plant as per equation 1.

Equation 1. Elliptical crown cover = (0.5*widest diameter) * (0.5*perpendicular diameter) * π

RESULTS

Survivorship in the first season post-outplanting was high at all sites ranging from 92% at Kirk East to 99% at Big Spires (Table 3). Survivorship of plants in the third year after outplanting (in control plots) was 59% at Eugene and 86% for Corvallis.

The areal cover of plants varied by site, particularly in the first year; plants were larger at the Finley sites than at Fern Ridge (Figure 8). This was not unexpected as in 2011, the Fern Ridge plants were smaller at the time of outplanting. In general plants from Field 29 were significantly larger than those from Finley Field 8N. An undergraduate student Emily Day from the OSU Honors College will be investigating potential soil effects with a greenhouse study underway as of Spring 2014.

Overall, plants were larger at Finley (Corvallis West Recovery Zone) and produced more capitula than plants in Eugene West Recovery Zone (Table 3, Figure 7). In the Eugene West Recovery Zone plants at Kirk East were consistently larger than those at Applegate (Table 3, Figure 8).

Table 3. Table of the number of plants, survivorship and flowering plants at each site (independent of treatment). Data collected July 2011 (approximately 3 months after outplanting) and June 2012 and 2013.

	Corvallis West Finley		Eugene West Fern Ridge	
	Field 8	Field 29	Applegate	Kirk
Number outplanted in 2011	450	450	360	356
2011 Number (%) survival	426 (95%)	428 (95%)	342 (95%)	327 (92%)
2011 Number flowering	2	6	1	0
2011 Average size (cm^2)	67	81	31	45
2012 Number (%) survival (2011-2012)	347 (81%)	365 (85%)	144 (42%)	198 (61%)
2012 Number flowering	195 (56%)	240 (66%)	60 (42%)	86 (43%)
2012 Average size (cm^2)	249	239	158	211
2013 Number (% Survival) (2011-2013)	285 (67%)	388 (91%)	181 (53%)	210 (64%)
2013 Number flowering	97 (34%)	269 (69%)	73 (40%)	81 (39%)
2013 Average size (cm^2)	36	123	60	57

Treatment Effects on Willamette Daisy

Survivorship

Survivorship varied by site, however there were no significant treatment effects on the survivorship of Willamette daisy.

Survivorship of individuals outplanted in 2011 and monitored in 2013 ranged from 48-67% in treatment plots in the Eugene West Recovery Zone, and 67%-89% in the Corvallis West Recovery Zone. The apparent lack of treatment effects on survival of Willamette daisy can be interpreted as an indication that though endangered, Willamette daisy can handle aggressive (but well-timed) management treatments without significant detrimental effects. Monitoring in 2014-2015 will track longer term treatment effects on the daisies that may not yet be evident.

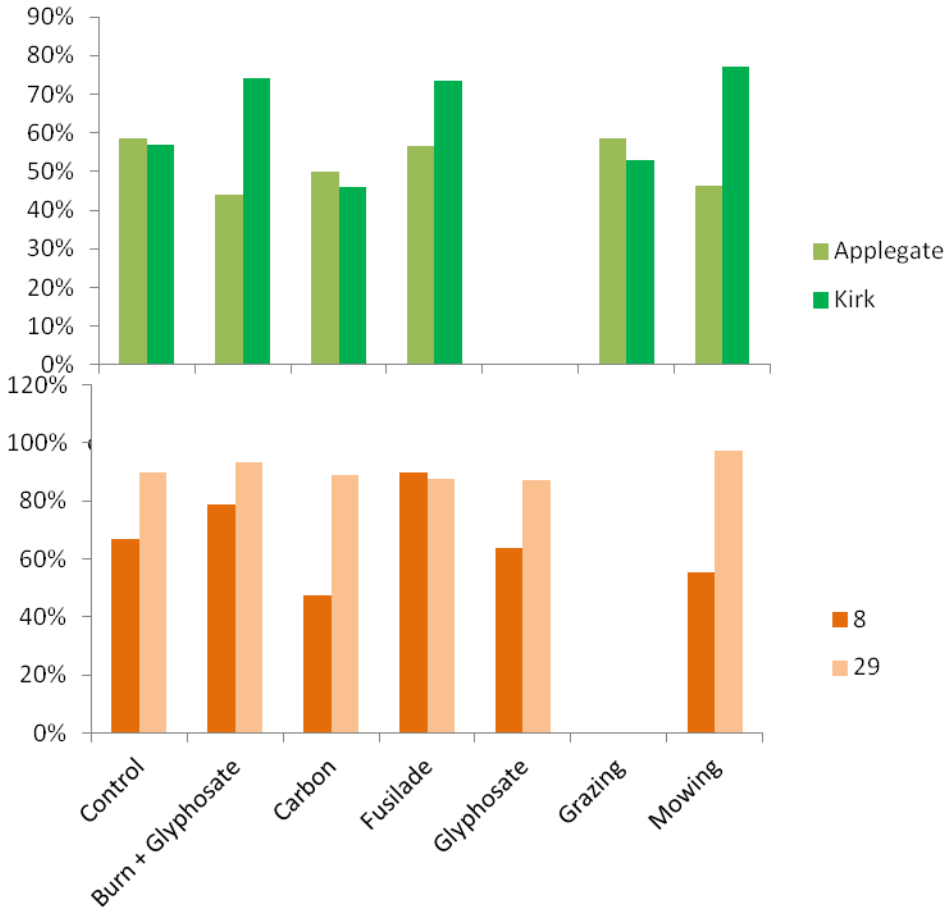


Figure 6. Percent survivorship from 2011-2013 at the Eugene West and Corvallis West Recovery Zones. Survivorship was higher overall at the Corvallis West sites. There was not a significant effect of treatment on survival.

Reproductive Success

Initial monitoring in 2012 indicates that only one treatment at one site had a significant effect on the reproductive success of Willamette daisy: the Burn + Glyphosate treatment at Finely, Field 29 (Corvallis West Recovery Zone), had significantly more flowers than the control (Figure 6).

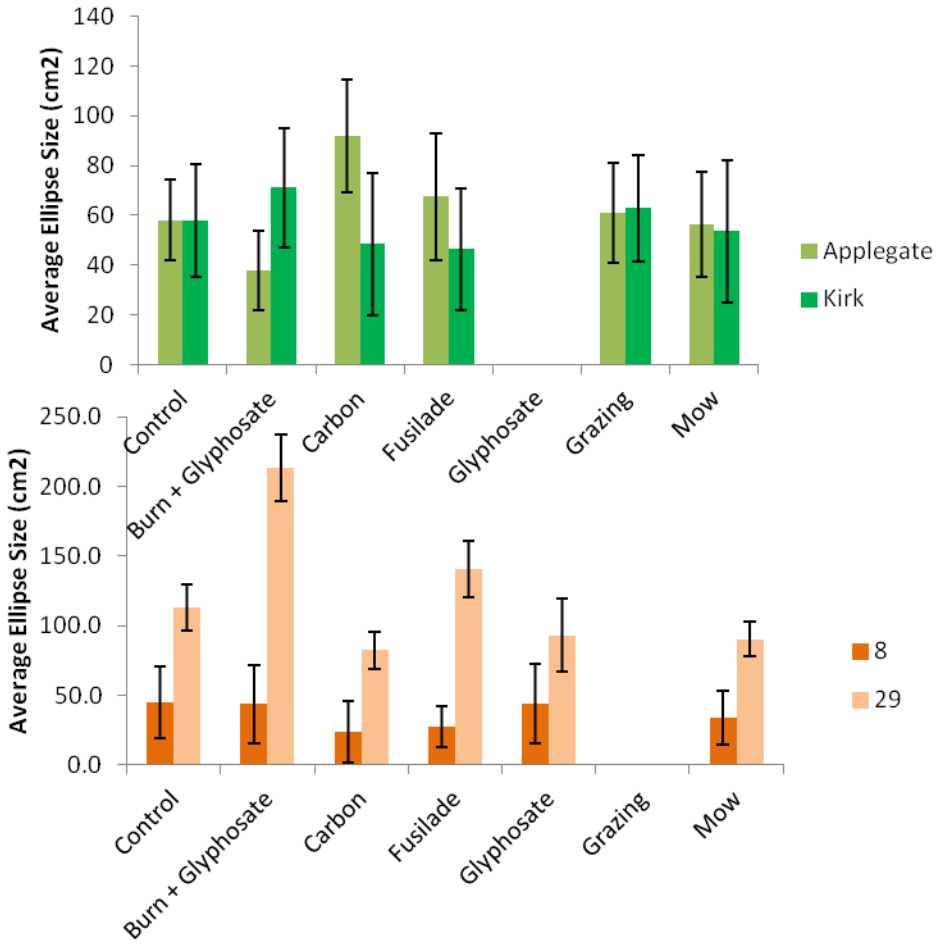


Figure 7. Average number of capitula in 2012 at the four sites outplanted in 2011. Note that the Eugene West sites (Applegate and Kirk East) have less capitula than the Corvallis West sites (Field 8 and Field 29). Grazing did not occur at the Corvallis Sites, the 'Glyphosate Only' treatment occurred only in the Corvallis West Recovery Zone. Error bars represent ± 1 Standard Error. Note that at Finley Field 8 there was a significant response from the 'Burn + Glyphosate' treatment resulting in more capitula per plant than the control (or any other treatment).

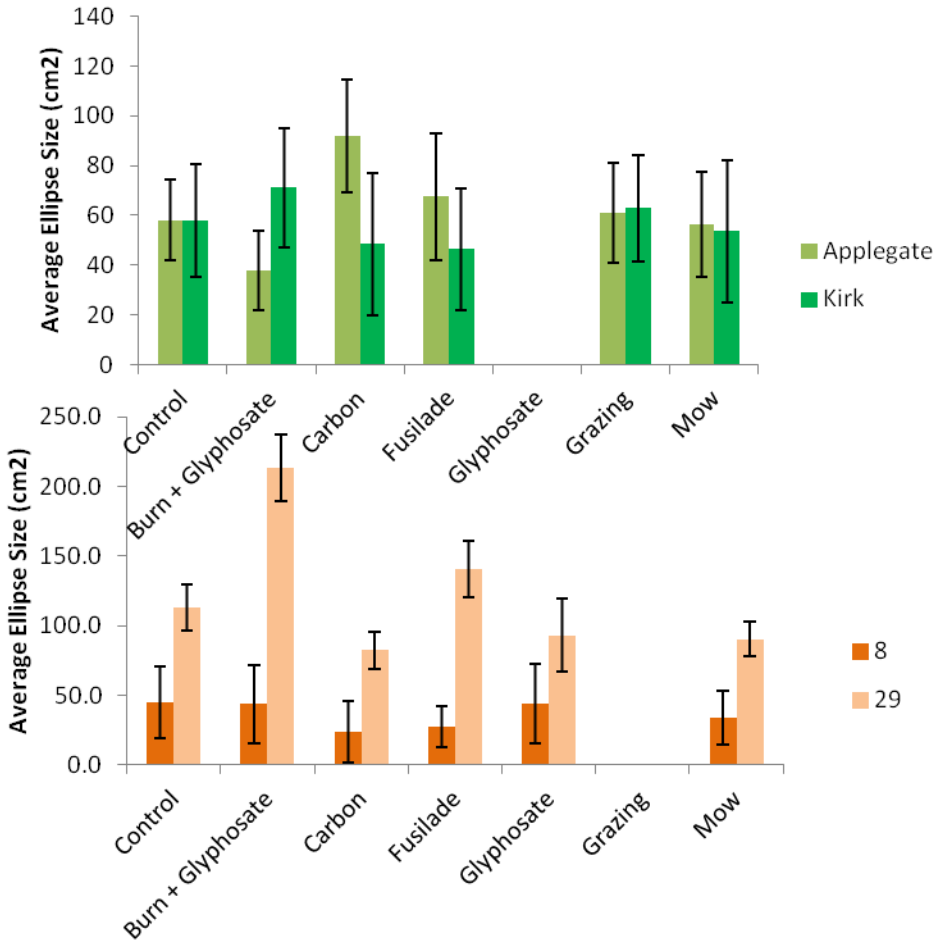


Figure 8. Ellipse size (cm^2) of Willamette Daisy at both the Eugene West and Corvallis West REcovery Zones. There was not a significant effect of any treatment on the size of the plants. As with capitula, the plants from the Corvallis West Recovery zone were consistently larger than those from the Eugene West Recovery Zoned independent of treatment.

Treatment Effects on Plant Community

The initial site conditions differ between the Corvallis and Eugene sites. Sites at Finley Wildlife Refuge are dominated by invasive forbs and tend to have more annual invasive grasses whereas sites at Fern Ridge are dominated by invasive perennial grasses. Below is an average of site conditions across all plots. Data reported here was recorded in the spring of 2012 and here is presented as an average across all treatment blocks.

The dominant vegetation at Fern Ridge (Eugene West Recovery Zone) is invasive grasses with an average cover of 61.6% and invasive forb cover of 10.4%. Dominant invasive grasses at Fern Ridge include the perennial species *Anthoxanthum odoratum* and *Agrostis stolonifera* each with an average of 30% cover, additional invasive species include *Festuca arundinacea* and *Panicum occidentale*. Annual invasive grasses at Fern Ridge have very low cover. In 2012, native grass cover was only 9.2% with 5.4% represented by *Danthonia californica.* Average native forb cover at Fern Ridge is 5.7% and was dominantly attributed to *Fragaria virginiana* and *Aster hallii*. Invasive forb cover has an average of 10.4% cover and is dominated by *Hypochaeris*

radicata (4.5%), *Plantago lanceolata* (2%) and *Leucanthemum vulgare* (1%). Tree and shrub cover is relatively high at the Fern Ridge sites with an average cover of 13.3%; dominant species include *Rosa sp.* (8%), *Cytisus scoparius* (2.2%) and *Rubus armeniacus* (2.2%) (Figure 9).

At Finley National Wildlife Refuge (Corvallis West Recovery Zone) the sites are dominated by invasive forb cover with an average of 63.2% and only 30.9% cover of invasive graminoids. Tree and shrub cover is relatively low with only 1.7% cover of mostly *Rubus armeniacus*. The dominant invasive forb species as at Fern Ridge is *Hypochaeris radicata*, with an average cover of 52.3%. Native forb cover is 15.8 % and is dominated by *Eriophyllum lanatum* (8.6%), *Lupinus spp.* (3.9%), and *Potentilla gracilis* (2.0%).

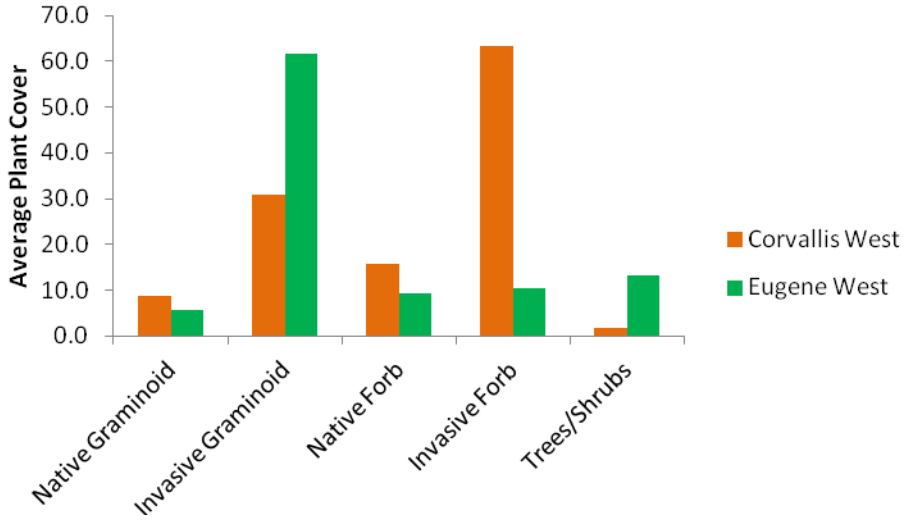


Figure 9. Average plant cover by functional group in 2012 for *Erigeron decumbens* outplanting sites in the Corvallis West and Eugene West Recovery Zones. Note that the initial site conditions vary in each Recovery Zone.

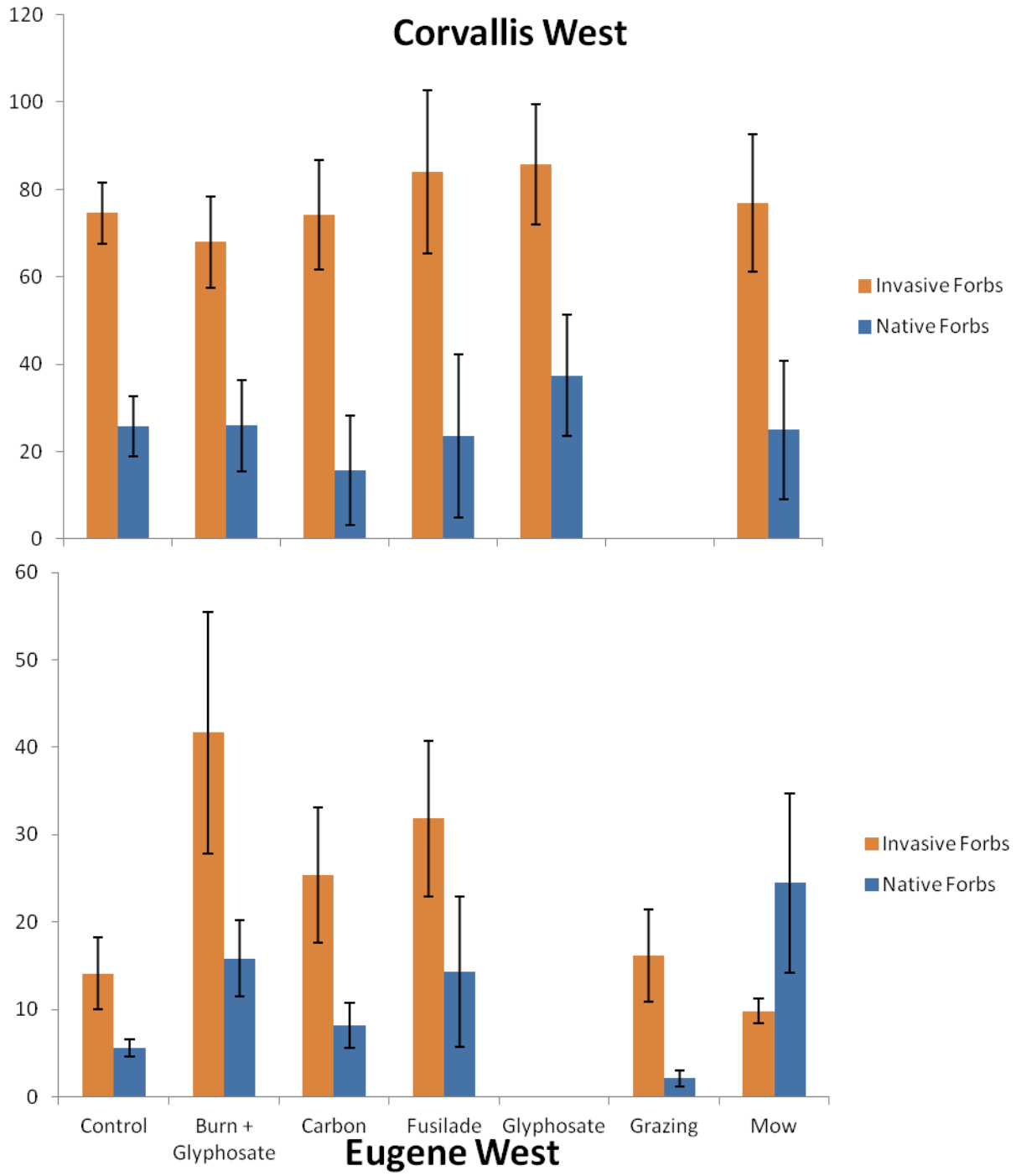


Figure 10. Percent cover of native and invasive forbs by treatment in both the Eugene and Corvallis West Recovery Zones in 2013. Error bars represent ± 1 Standard Error.

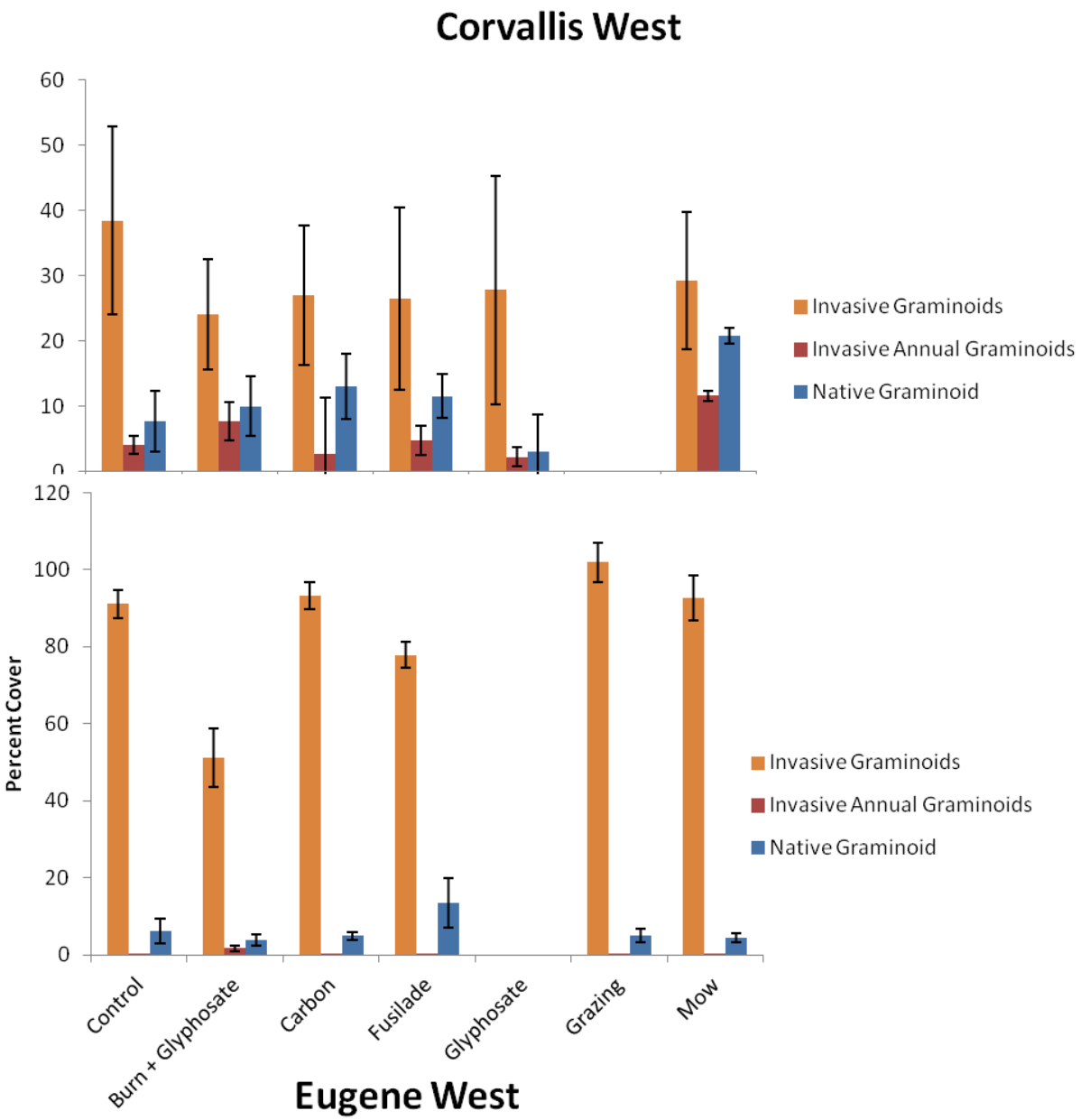


Figure 11. Percent cover of native and invasive graminoid species recorded in 2013 at sites in the Eugene West and Corvallis West Recovery Zones.

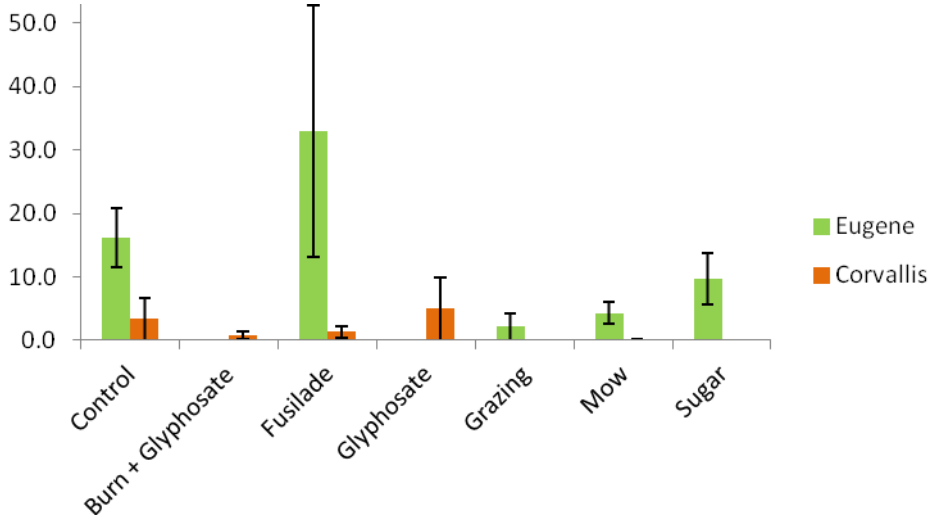


Figure 12. Percent shrub cover in 2012 for both the Eugene and Corvallis West Recovery Zones. Native and invasive species are lumped together.

Mowing

Mowing did not have a significant effect on graminoid or forb cover (native or invasive) in either Recovery Zone. Shrub cover in the Eugene West Recovery Zone decreased with mowing.

Grazing (Fern Ridge only)

Grazing by sheep in the Eugene West Recovery did not have a significant effect on graminoid or forb cover (native or invasive). Shrub cover decreased significantly in plots grazed by sheep. Mowing also decreased cover of shrubby species in the Eugene West Recovery Zone.

Grass-Specific Herbicide

The application of a grass specific herbicide decreased cover of invasive graminoid species in both Recovery Zones; native graminoid cover was not or increased. The application of grass-specific herbicide increased shrub cover in the Eugene West Recovery Zone.

Burning + Glyphosate

The application of a broad-spectrum herbicide after the first flush of green-up post-burn decreased cover of invasive grasses and invasive forbs in the Corvallis West Recovery Zone; native graminoids and forbs were not affected. Burning occurred in the Fall of 2012 at Eugene West sites, and decreased invasive graminoids (but increased invasive forbs).

Glyphosate (Finley only)

The application of glyphosate in the fall had no significant effect on the cover of native or invasive species.

Carbon Addition

As of 2013, carbon addition had no significant effect on the cover of native or invasive forb species, however carbon addition did tend to decrease cover of native graminoids in the Corvallis West Recovery Zone.

The plant community response may take time to be detected and monitoring in 2014 and 2015 should elucidate any longer term effects of treatments on both the plant community and the Willamette daisy: it is not uncommon for multiple treatments to be applied before response can be detected. Repeated treatments as well as continued monitoring will enable us to detect longer term changes in both the plant community and success of Willamette daisy individuals.

FUTURE ACTIVITIES

The activities reported here are part of a 3-phase, 6-year project (Table 4). In Phase 1/2, we have introduced populations of Willamette daisy, implemented 2 years of habitat treatments, and monitored the effects on Willamette daisy and surrounding vegetation. We are currently, in the process of completing Phase 3 which will include treatments and monitoring of plots outplanted in 2011 and 2013, as well as analysis of all data collected over the course of the study. This will include management recommendations for the species at each site included in the study. We plan to use the information gained from all phases to inform management at both introduced and natural populations of Willamette daisy.

Table 4. Timeline of activities to determine effects of management on Willamette daisy.

Project Element	Timeframe	Description
Phase 1/2		
Complete site selection and experimental design	Spring '10, ***Complete***	Fern Ridge Natural Area (ACOE) and Finley National Wildlife Refuge (USFWS) selected for introductions and experiments.
Seed collection and cleaning	July – Aug '10, ***Complete*** July – Aug '11, ***Complete***	As needed, we will collect seed from natural populations to augment seed currently in production.
Growout	Oct '10 – April '11, ***Complete*** Oct '12 – April '13[1], Complete	Willamette daisy grow-out will include four months of cold stratification, then propagation of seedlings in our greenhouse located at Oregon State University.
Introduce Willamette daisy	April '11, ***Complete*** April '13[1], ***Comp;ete***	Outplant seedlings.
Demographic, population, and community monitoring	May - June '11, ***Complete*** May - June '12, ***Introductions only***	Monitoring will include demographic and population monitoring of Willamette daisy and cover estimate of all species.
Implement management treatments	Fall '11 – Spring '12 ***Complete*** Fall '12 - Spring '13 ***Complete***	Mowing, thatch removal, grazing, and herbicide treatments will occur during the growing season, but before Willamette daisy is susceptible to damage. Fall burning will be implemented using propane torches. Each treatment will occur twice.
Project and fiscal oversight	ongoing	On-going through-out project.
Status reporting	'13 –'14	Prepare reports and communicate results through the IAE webpage and meetings.
Phase 3		
Adapt and implement methods at new sites	Spring '13, '14, ***Complete***	We will use the information obtained from Phase 1 of this project to guide implementation of management treatments at existing populations and new introduction sites.
Demographic, population, and community monitoring	May - June '13, '14, '15, ***In Progress***	Monitoring will include demographic and population monitoring of Willamette daisy and cover estimate of all species.
Project and fiscal oversight	ongoing	On-going through-out project.
Post-Implementation status reporting	'15 – '16, In progress, ***Pending funding***	We will prepare reports and communicate results through the IAE webpage, meetings, and conferences.

[1]Dates altered relative to original proposal.

LITERATURE CITED

Alpert, P., and J.L, Maron. 2000. Carbon addition as a countermeasure against biological invasion by plants. Biological Invasions, **2**, 33-40.

Boyer, L. 2008. Krautmann Jefferson Farm oak and prairie habitat restoration Project. LIP progress report 2. Available at http://www.heritageseedlings.com/stewardship.htm

Blumenthal, D.M., N.R. Jordan, and M.P. Russelle. 2003. Soil carbon addition controls weeds and facilitates prairie restoration. Ecological Applications, **13**, 605-615.

Floberg, J., M. Goering, G. Wilhere, C. MacDonald, C. Chappell, C. Rumsey, Z. Ferdana, A. Holt, P. Skidmore, T. Horsman, E. Alverson, C. Tanner, M. Bryer, P. Iachetti, A. Harcombe, B. McDonald, T. Cook, M. Summers, D. Rolph. 2004. Willamette Valley-Puget Trough-Georgia Basin Ecoregional Assessment, Volume One: Report. Prepared by The Nature Conservancy with support from the Nature Conservancy of Canada, Washington Department of Fish and Wildlife, Washington Department of Natural Resources (Natural Heritage and Nearshore Habitat programs), Oregon State Natural Heritage Information Center and the British Columbia Conservation Data Centre.

Kirkpatrick, H., E. Spear, E. Donnelly. 2006. Soil nitrate reduction using biomass removal and sucrose addition in western Washington prairie soils. Ecological Society of America Annual Meeting. Memphis, Tennessee. Poster presentation.

Morgan, J.P. 1994. Soil impoverishment: a little-known technique holds promise for establishing prairie. Restoration and Management Notes, **12**, 55-56.

Noss R.F., E.T. I. LaRoe, and J.M. Scott. 1995. Endangered ecosystems of the U.S.: a preliminary assessment of loss and degradation. Washington, D. C.: U.S. Department of the Interior, National Biological Service.

[ORBIC] Oregon Biodiversity Information Center. 2010. Rare, threatened and endangered species of Oregon. Portland (OR): Institute for Natural Resources, Portland State University. 105 p.

Pfeifer-Meister, L., S. D. Bridgham, B. A. Roy, and B. Johnson. 2007. Testing the effectiveness of site preparation techniques for wetland prairie restoration. City of Eugene, Eugene, Oregon.

Reever Morghan, K.J., and T.R. Seastedt. 1999. Effects of soil nitrogen reduction on nonnative plants in restored grasslands. Restoration Ecology, **7**, 51-55.

Stanley, A.G., T.N. Kaye, and P.W. Dunwiddie. 2008. Regional strategies for restoring native prairies: observations from a multisite collaborative research project. Native Plants Journal 9:255-266.

Stanley, A. G., P. Dunwiddie, and T. N. Kaye. 2010. Regional strategies for restoring invaded prairies, final technical report Institute for Applied Ecology and The Nature Conservancy, Corvallis, Oregon.

Thorpe, A.S., and T.N. Kaye. 2011. Issues in the conservation and introduction of the endangered *Erigeron decumbens*: seed viability and the influence of local adaptation. Native Plants Journal 12:289-298.

Thorpe, A.S, and T.N. Kaye. 2007. Erigeron decumbens ssp. decumbens (Willamette daisy): population monitoring and evaluation of mowing and burning at Oxbow West (West

Eugene Wetlands). Institute for Applied Ecology, Corvallis, Oregon and USDI Bureau of Land Management, Eugene District. iii + 26pp.

[USFWS] U.S. Fish and Wildlife Service. 2010. Draft Recovery Plan for the Prairie Species of Western Oregon and Southwestern Washington. U.S. Fish and Wildlife Service, Portland, Oregon. x + 212 pp.

APPENDIX A PLANTING LOCATIONS AT FINLEY NATIONAL WILDLIFE REFUGE

Field 29:

From Corvallis drive south to Finley National Wildlife Refuge.
Park at the Woodpecker Loop Trailhead
Walk South uphill to series of t-posts and plots. (There are lots of other plots in the area, including CALE and other ERDE plots.) The 2011 plot is marked with a t-post in the NE corner and the remaining plot corners are marked with square concrete markers flush with the ground. Treatment squares are marked with nail/whisker combinations.

ERDE Management plot locations at Field 29, Finley National Wildlife Refuge

ERDE Management plot locations at Field 8N, Finley National Wildlife Refuge

Field 8N

From Corvallis Drive South on Hwy 99.

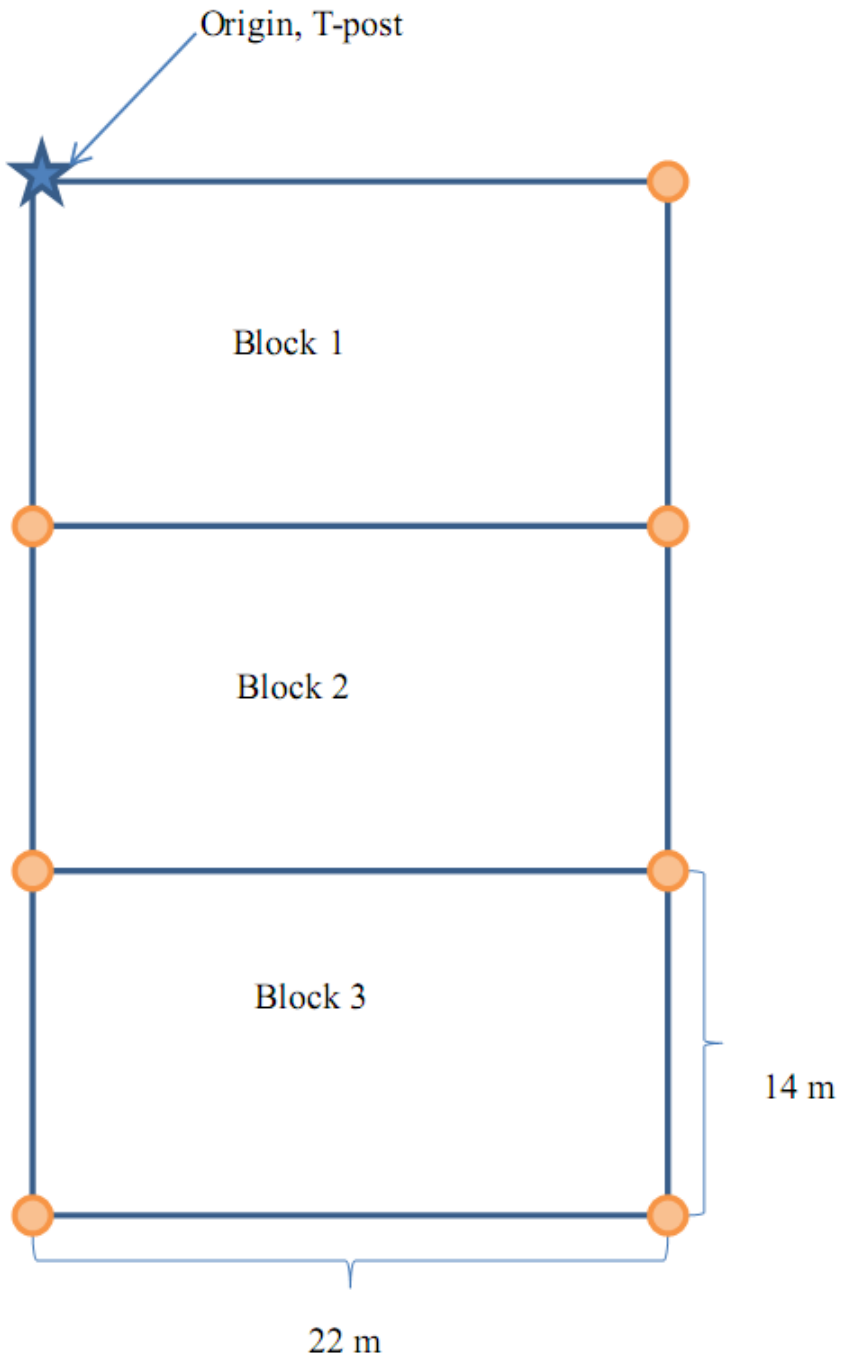
Turn Right (west) onto Bruce Rd.

After ## miles take gated road on right (unmarked)- this is across the street from an overview/lookout.

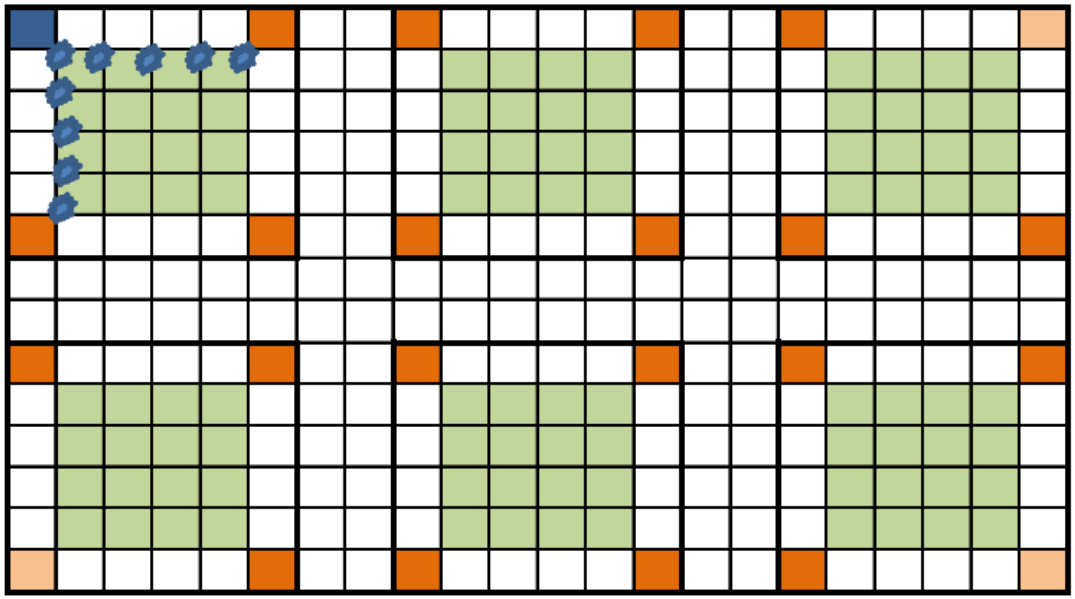
Continue along road 0.3 miles and park on roadside, walk to site.

The NE corner of the 2011 plot is marked with a t-post.

Macroplot design at Finley National Wildlife Refuge.
Blocks at both Field 29 and Field 8 were placed adjacent to each other. The origin is marked with a T-post and the remaining corners are marked with rebar topped with orange caps pounded flush with the ground.



Layout of blocks and treatment plots at Finley National Wildlife Refuge.



= T post and Whisker

= Orange capped rebar

= whisker with spike

= planting area. Start planting at meter 1 to meter 5
Planted block will be 5m x 5m

= 1m x 1m

= ERDE

APPENDIX B PLANTING LOCATIONS AT FERN RIDGE NATURAL AREA

ERDE Management plot locations at Kirk East, Fern Ridge Natural Area

From Corvallis Drive south on HWY 99.

Just north of Beltline turn right (west) onto Clear Lake Road.

After ## miles turn right onto Orchard Rd, and immediately pull into parking lot for Kirk Pond.

Follow path to site.

ERDE Management plot locations at Applegate, Fern Ridge Natural Area

Applegate:
From Corvallis Drive south on Hwy 99.
Turn onto Clear Lake Drive
Turn left onto the Territorial Highway (or take Territorial from Monroe)
5.7 miles after Clear Lake/ Territorial Junction, turn left into ACOE pull-out. This parking lot/pullout is just north of Fir Grove Ln. – If you enter town, you have gone too far.

Atlantic/Pacific:

Atlantic/Pacific:

From 126/West 11th Turn North onto Danebo.

Pass the red house (on the right-WEW office)

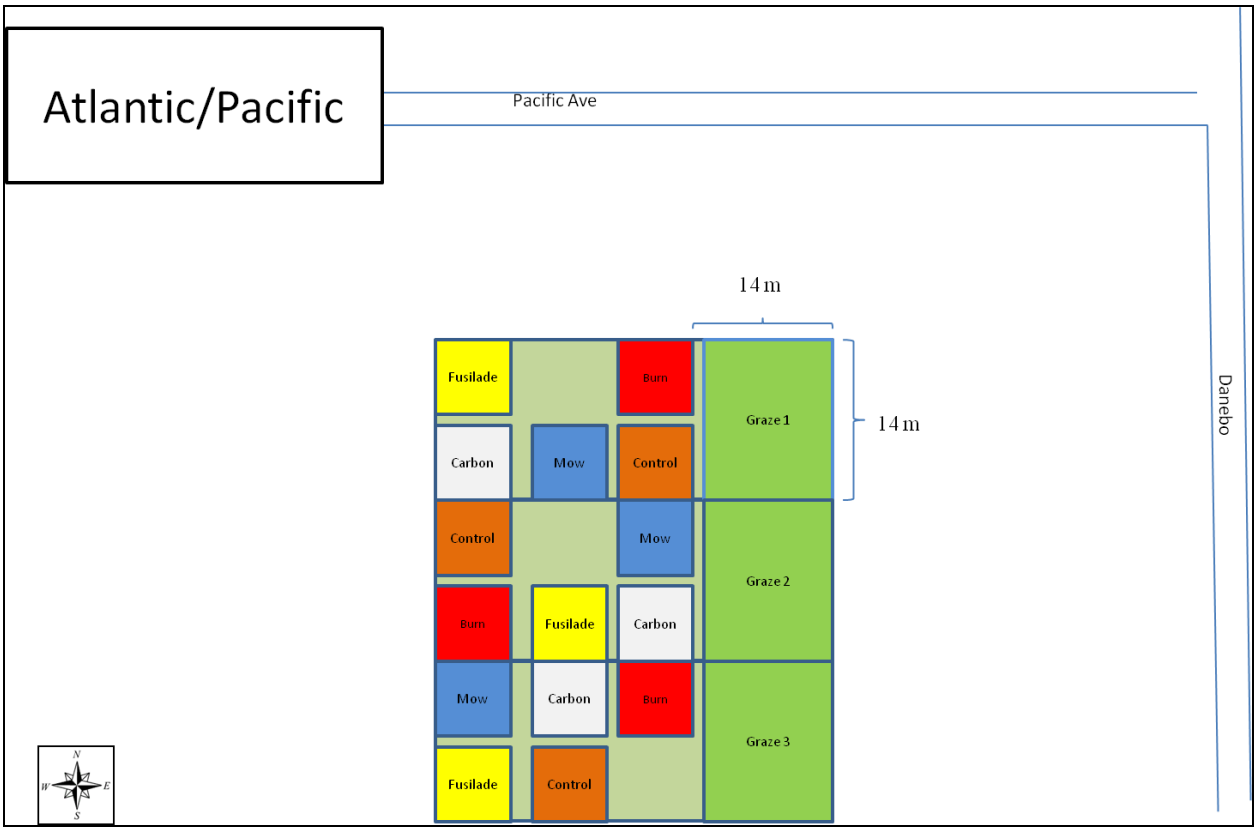
Turn left onto Pacfic Ave.

Park at junction of Atlantic/Pacific and walk to site.

Alternatively, take Beltline (Hwy 569, Randy Pape Beltline) and take the Roosevelt St. Exit.

Left onto Danebo and then Right onto Pacific Ave

(If you see the red house on your left you have gone too far.)



Big Spires:

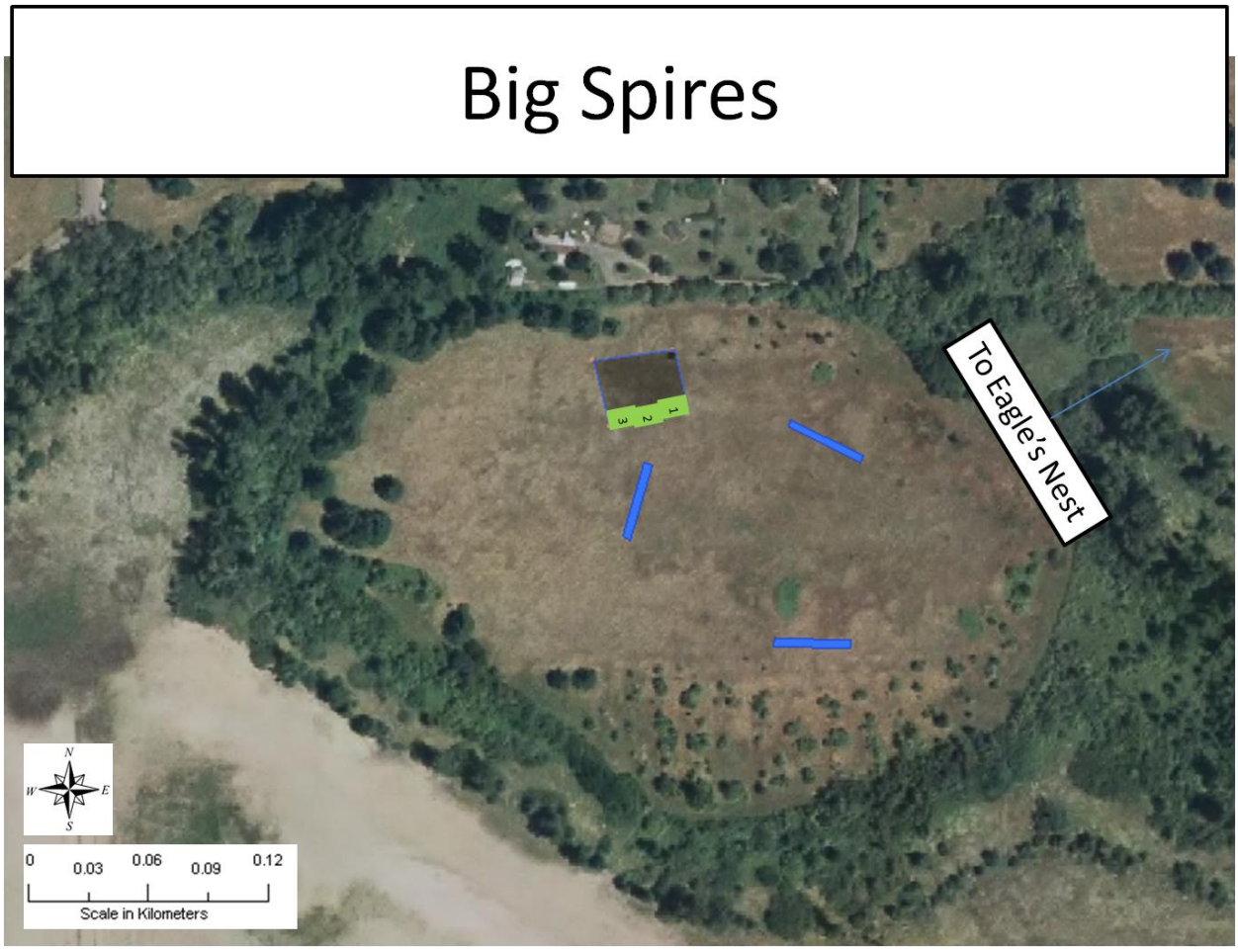
From Corvallis drive south on Hwy 99W

Turn west onto Clear Lake Drive. (Just North of Beltline)

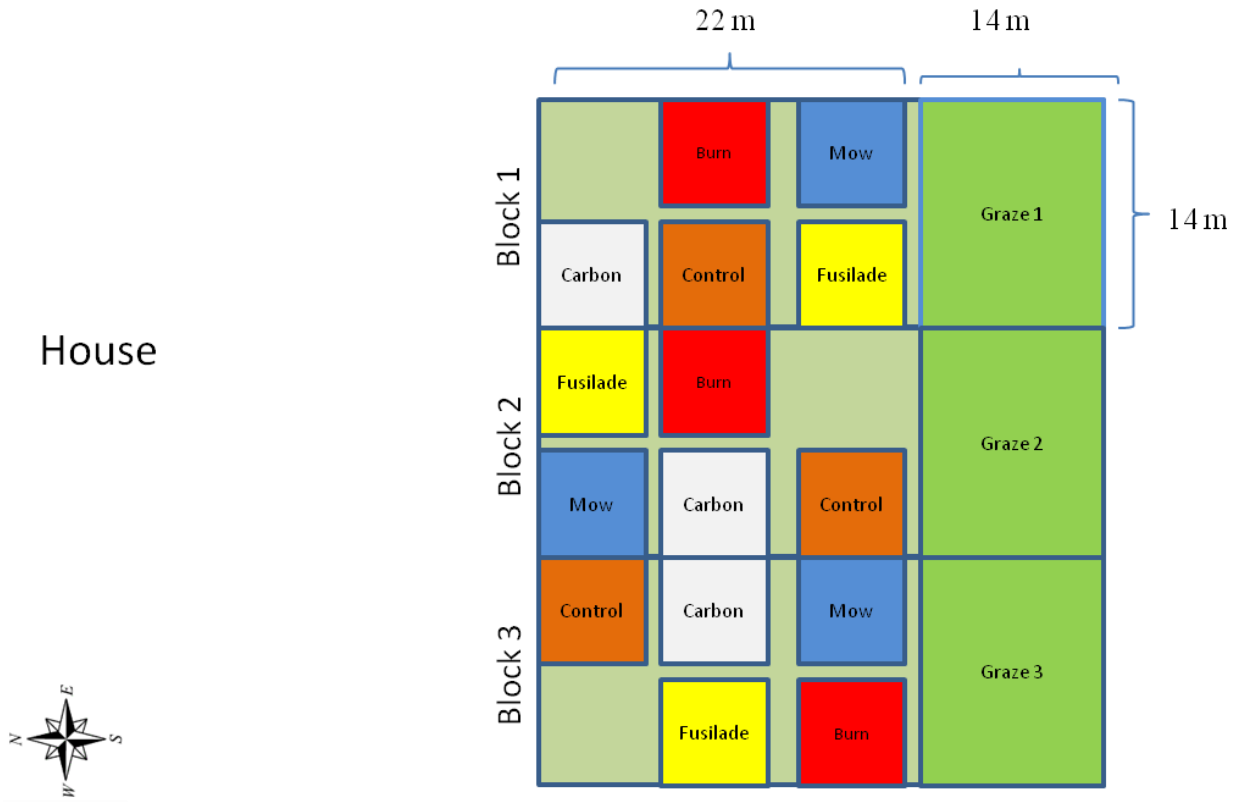
After 4.6 miles turn left onto Spires Lane (along sweeping S-curve)

Park at pull-out near mailboxes at 0.4 miles. (Do not block gate or adjacent roads.)

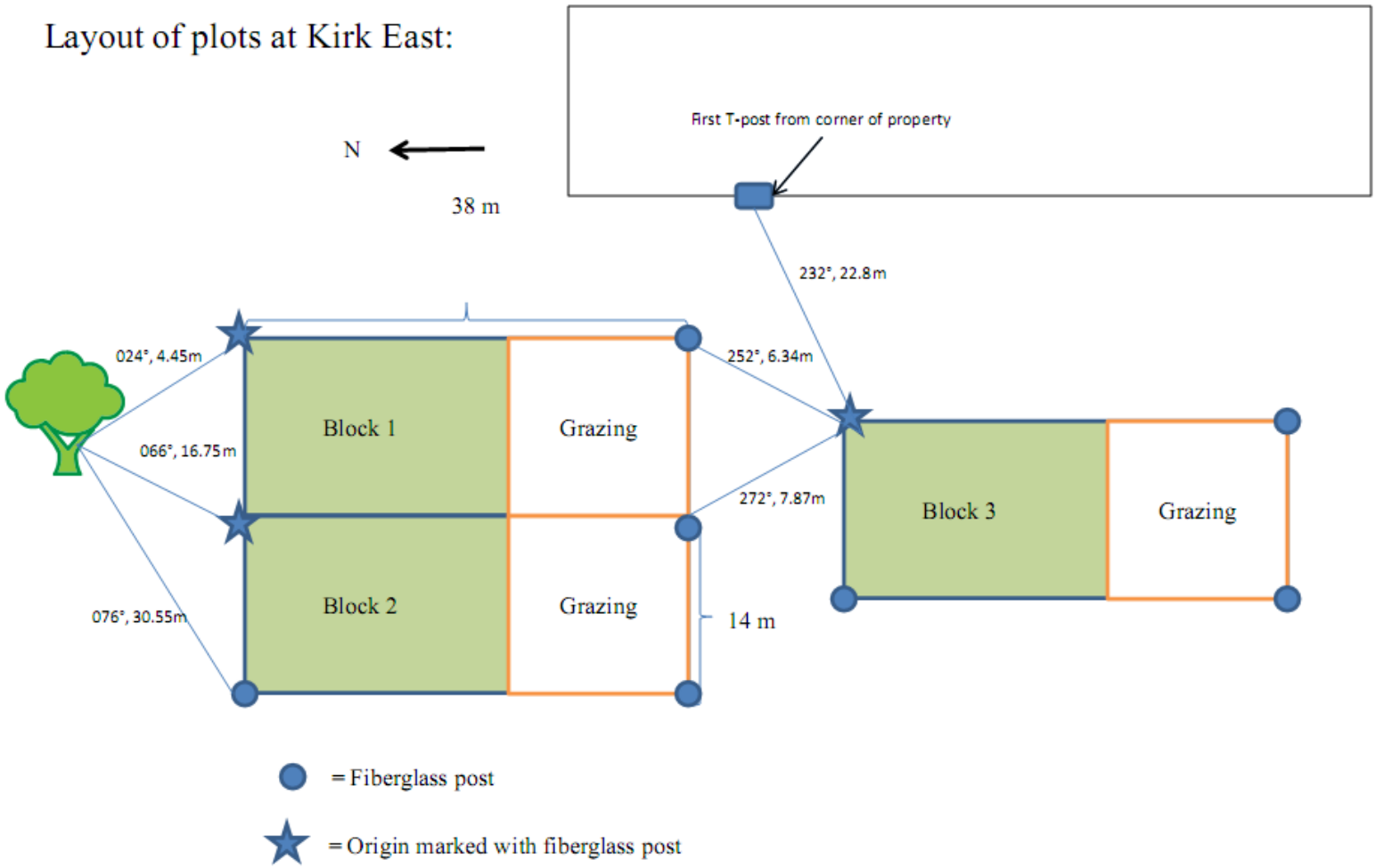
There is a bald eagle nest at the site.



Big Spires Plot Layout:



Layout of plots at Kirk East:

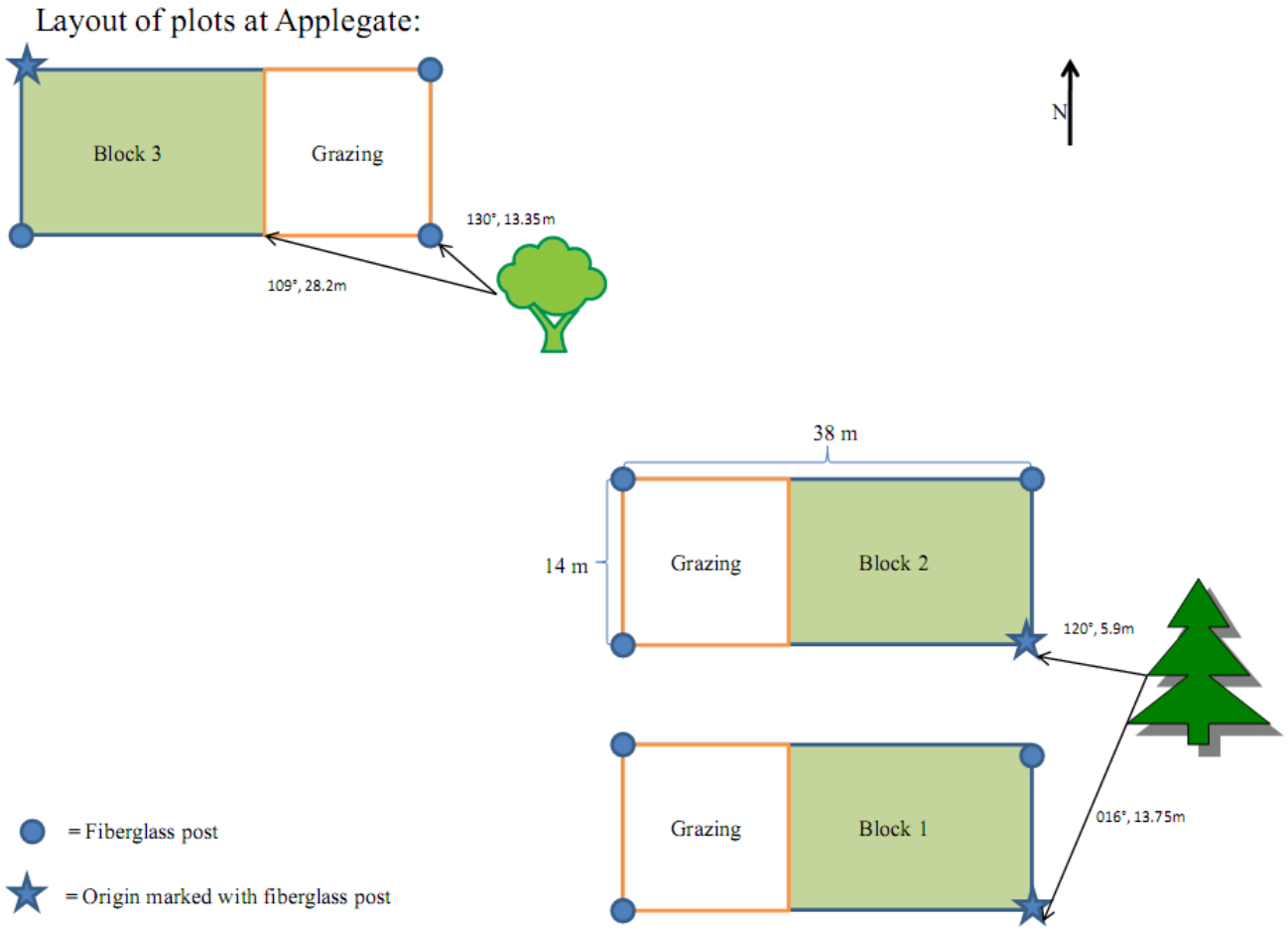


Generalized Plot Layout for Plots at Kirk East, ACOE, Eugene Recovery Zone:

1 Burn	2 empty	3 Fusilade	Grazing
4 Mow	5 Control	6 Sugar	

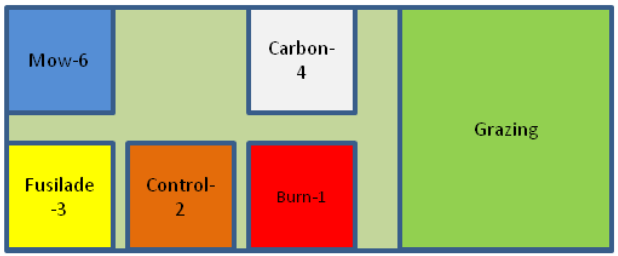
1 Mow	2 Sugar	3 Empty	Grazing
4 Burn	5 Control	6 Fusilade	

1 Fusilade	2 Mow	3 Burn	Grazing
4 Sugar	5 empty	6 Control	



Macroplot design at Applegate, Fern Ridge Natural Area.
During set-up and treatments, the origin of each block is marked with a T-post and the remaining corners are marked with rebar topped with orange caps pounded flush with the ground. In the intervening times, plots are only marked with 8 inch nails and colored whiskers in order to minimize visibility. Map not to scale; there is greater distance between Block 3 and the remaining blocks than indicated on the map.

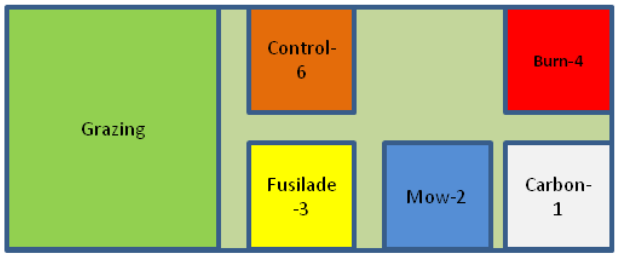
Block 3

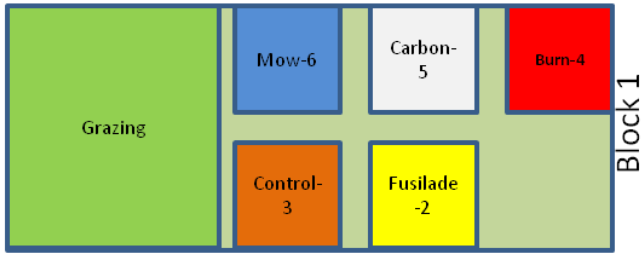


Applegate

N

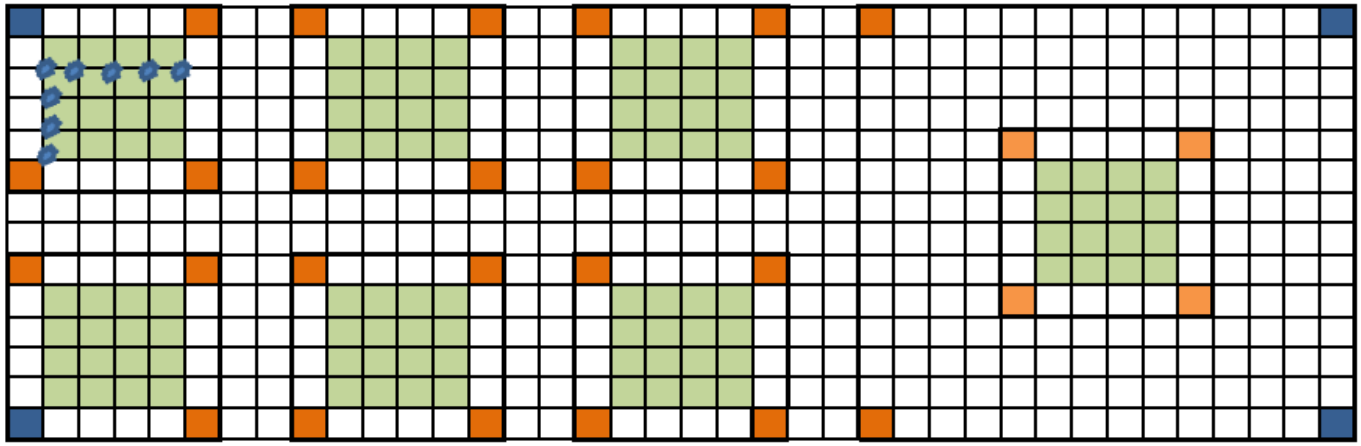
Block 2





Layout of blocks and treatment plots in the Eugene Recovery Zone

One small treatment plot was randomly excluded from planting; in 2011 one planting row or column within each square was skipped due to limitations of plant materials.



= Fiberglass post and Whisker

= whisker with spike

= planting area. Start planting at meter 1 to meter 5
Planted block will be 5m x 5m. One row or column will be skipped in each square

= 1m x 1m

= ERDE