

Restoration of Willamette Valley Upland Prairies at Fern Ridge Lake



2015

Progress Report and Restoration Plan

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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.



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Cover photograph: Upland prairie habitat at East Spires, 2015

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Restoration of Willamette Valley Upland Prairies at Fern Ridge Lake

A REPORT PREPARED FOR U.S. ARMY CORPS OF ENGINEERS,
WILLAMETTE VALLEY PROJECTS

INTRODUCTION

Upland prairies in the Willamette Valley are among the most endangered ecosystems in North America, and support many imperiled species. Two of these species are the threatened plant *Lupinus oregonus* (Kincaid's lupine, Figure 1) and endangered Fender's blue butterfly (*Icaricia icarioides fenderi*).

Lupinus oregonus is currently known at about 164 sites, comprising 246 hectares (USFWS 2010). The majority of these 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. Fender's blue butterfly currently occurs in approximately 44 sites in the Willamette Valley (Mikki Collins, personal communication). Approximately half of these sites are on federal, state, county, or city lands; the remainder are on private lands.

Approximately 100 acres of occupied or potential habitat for Fender's blue butterfly and *L. oregonus* is under management at Fern Ridge Lake. The eleven sites in this project are particularly valuable as they have several layers of administrative protection. The Fern Ridge master plan provides them with wildlife habitat or environmentally sensitive land use designations; the current rare species management plan and Biological Opinion place primary emphasis on activities to benefit listed species; and all sites except one are designated Critical Habitat for Fender's blue butterfly, *L. oregonus*, or both.

Current population sizes of these species are similar to other important sites, including Basket Butte, in the Salem West Recovery Zone, and Willow Creek, in the Eugene West Recovery Zone. These populations are also a vital portion of a potentially connected, functioning network of Fender's blue butterfly sub-



Figure 1. The endangered Fender's blue butterfly on the threatened Kincaid's lupine. Both species are native to upland prairies in the Willamette Valley

populations as they are close to Fir Butte (managed by the West Eugene Wetlands) and other stepping stone sites between Fern Ridge and Eugene.

The sites in this project have been mowed since the 1970's. Mowing was originally intended to maintain habitat for upland birds, but it also allowed native plants to persist despite the presence of aggressive invasive plants, *Arrhenatherum elatius* including (tall oat grass), *Cytisus scoparius* (Scotch broom), and *Rubus* spp. (blackberries). Fender's blue butterfly and *L. oregonus* were first identified in 1998 and have since been the primary targets for management. Increasingly intensive management has resulted in increased butterfly numbers, *L. oregonus* cover, and habitat quality. *L. oregonus* and nectar species plantings have yielded over 4,000 new plants and more than 500 m² of lupine leaf area. The population of Fender's blue butterfly has increased from an initial estimate of 17 adult butterflies to approximately 1282 butterflies in 2009. In 2010, it was estimated that there were roughly 1135 Fender's blue butterflies at Fern Ridge.

The goal of this project is to build upon these efforts and restore a matrix of native prairie grasses with moderate native forb diversity (emphasizing host and nectar plant species for Fender's blue butterfly). In each of seven sites (or combinations of adjacent sites), we will create a hectare of high-quality habitat for Fender's blue butterfly, which has been identified as the minimum patch size that will allow long-term persistence of Fender's blue butterfly.

METHODS

Treatments

The treatments recommended for this project were based on several long-term restoration projects in the Willamette Valley, including restoration in the West Eugene Wetlands (T. Taylor, *personal communication*), in Wetland Restoration Enhancement Program sites (M. Blakeley-Smith, *personal communication*), and upland prairies in the Willamette Valley and Puget Trough (Boyer 2008; Stanley et al. 2008; Amanda Stanley, *personal communication*).

At several sites, we recommend following a "matrix treatment" (Table 1) for two years. After this period, different treatments will be followed based on the composition of the initial plant community (Table 1). We will also apply several small-scale treatments that have the potential to increase restoration success, but are either relatively new restoration techniques or are prohibitively expensive to apply on a large scale. These treatments will include solarization, pre-emergent herbicides, pre-emergent herbicides combined with carbon banding, and sucrose addition.

As the matrix treatment is relatively aggressive and should result in elimination of most or all species occupying the site, it is not appropriate for sites currently supporting *Lupinus* or large populations of nectar species. At these sites, we will make specific treatment recommendations based on site-specific species composition.

All sites were monitored annually starting the first year of scheduled treatments. At each site, we randomly selected plots and estimated the percent cover of all vegetation. Data from the first several years of sampling has been used to guide the selection of restoration treatments.

In addition to conducting large scale treatments, there were several introduced species in the restoration sites that required special treatment, including *Cytisus*, *Rubus*, and *Centaurea pratensis* (meadow

knapweed). We recommend these species be treated using herbicides or grubbing each year until eliminated.

Table 1. General treatment schedule for upland prairie restoration at Fern Ridge Lake. This schedule was revised February 2011, based on treatment effects as described in this report.

Year	Season	Treatment
“Matrix” treatment		
Yr 1	Spring	Spray with glyphosate or tank mix ¹
Yr 1	Fall	Burn, propane torch, hay, or mow
Yr 1	Fall	2 -4 weeks post-burn (or after other treatment): Glyphosate
Yr 1	Fall/Winter	If possible, spray with glyphosate a second time
Yr 2	Spring	Spray with glyphosate or tank mix ¹
Yr 2	Fall	Burn, propane torch, hay, or mow
Yr 2	Fall	2 -4 weeks post-burn: Glyphosate
Yr 2	Fall	Apply small-scale treatments
<i>Treatment for sites dominated by aggressive, weedy forbs</i>		
Yr 2	Fall	Seed with native grasses
Yr 3	Spring	Spray with broadleaf herbicide (e.g. 2,4-D)
Yr 3	Fall	Spray with broadleaf herbicide (e.g. 2,4-D)
Yr 3	Fall	Seed with clopyralid tolerant native forbs
Yr 4	Spring	Spray with clopyralid
Yr 4	Fall	Seed with diverse native forb mix
Yr 4	Fall	Seed with native forbs ²
<i>Treatment for sites dominated by aggressive, weedy grasses</i>		
Yr 2	Fall	Seed with native forbs
Yr 3	Spring	Spray with grass specific herbicide (e.g. Fluazifop)
Yr 3	Fall	Spray with grass specific herbicide
Yr 3	Fall	Seed with Fluazifop -tolerant native grasses
Yr 4	Spring	Spray with Fluazifop
Yr 4	Fall	Seed with diverse native grasses ²

Once restoration goals have been achieved, sites should be monitored at least annually to detect changes in vegetation (e.g. increased weed abundance). Site maintenance is likely to include regular prescribed fire followed within 1-2 weeks with glyphosate application, mowing, herbicide spot treatment, and other treatments as necessary.

¹Tank mix formulation should be site specific and generally include glyphosate + a more specific herbicide. Dicamba was used initially in combination with glyphosate as it is effective for legumes and has some residual effects. More recent applications using glyphosate + aminopyralid have had good weed control.

²Final seeding assumes that desired control of introduced species has been achieved. Final seeding may need to be delayed and treatments repeated.

BIG SPIRES

Restoration treatments were initiated at Big Spires spring 2008 (Table 2). This site is currently the furthest along in the restoration process of this project and can serve as an example for other sites and treatment regimes.

Monitoring

Botanical surveys were first completed at Big Spires in June of 2008, shortly after herbicide application. An x and y axis were superimposed on an aerial photo of the meadow (Figure 2) and coordinates were randomly selected for plot placement. The meadow at Big Spires is roughly the shape of an ellipse; randomly selected coordinates that were outside of the meadow were eliminated and replaced with another randomly selected location. Thirty plots were sampled.

Four T-posts were positioned every 90m along the x-axis beginning in the northwest end of the meadow. This axis extends 270m at 133°. The y-axis bisected (i.e. at 135m) the x-axis. This axis extended 110m to the northeast at 23° and 70m to the southwest. We placed a 1x1m sampling frame at the top right corner at each selected sampling point and estimated the percent cover of each species.

In May, 2010, we conducted a qualitative survey of the site, noting dominant vegetation and distribution and abundance of species of interest (e.g. valuable native species such as *Sidalcea* or previously dominant invasive species such as *Arrhenatherum elatius*). Due to substantial vegetation changes during the summer, additional treatments and quantitative surveys were deemed necessary in fall 2010. Similar sampling methods were used in October 2010, as in 2009, with the exception that there were no t-posts and plot locations were estimated from an approximate centerline. Qualitative surveys to document the presence and approximate site-wide cover of the most common plant species were repeated in May 2011. Quantitative monitoring occurred again in 2012, 2013, 2014 and 2015 at Big Spires.

Plantings

The most significant plantings at Big Spires has been 4 years of drilled and cross-drilled *Festuca roemerii*, including a final pass in fall 2013 after the fall burn. Additional broadcast seeding was done in the 2011/2012 season and again in 2013. Details of the specific seed mixes for these treatments are summarized in Appendix L.

Twenty 5x80m “diversity” plots were established in 2012. These plots were oriented E-W, marked with 6 pinflags, bamboo at NW corner (Figure 3). These plots were established to test the success of different native seed mixes. Western half designated seed mix “A”, eastern seed mix “B” (Appendix L). Density estimates are on the high side as we had left-over material.

Also in 2012, at the ends of selected diversity plots, lupine was seeded-in at about 30 seeds/m² in each of 5, 25m² plots (Figure 3). In addition, 3, 5x40m² plots were planted with *Castilleja levisecta*. These plots were marked with flagged and capped rebar, odd orientations, tall stake in each NW corner (Figure 3).

In 2013 we planted plugs of *Erigeron decumbens* for an experiment in management methods of this endangered species. Additional *Castilleja levisecta* plugs were planted in blocks throughout the site. Additional plug plantings and seeds were planted at Big Spires after the burn in fall of 2013. See Appendix L for detailed map of planting type, species, and location within the site.

Table 2. Treatment schedule for Big Spires at Fern Ridge Lake. 2008 was the first year of restoration treatments at this site.

Year	Season	Original Recommendations	Treatment	Actual
2007	Fall		Wildfire, east 1/3	
<i>"Matrix" treatment</i>				
2008	Spring	Spray with glyphosate or tank mix ¹	Broadcast glyphosate & dicamba	
2008	Fall	Burn, propane torch, hay, or mow	Hay	
2008	Fall	2 -4 weeks post-burn (or after other treatment): Glyphosate		
2008	Fall/Winter	If possible, spray with glyphosate a second time		
2009	Spring	Spray with glyphosate or tank mix ¹ .	Broadcast glyphosate	
2009	Fall	Burn, propane torch, hay, or mow		
2009	Fall	2 -4 weeks post-burn: Glyphosate	Broadcast glyphosate	
2009	Fall	Apply small-scale treatments		
<i>Treatment for sites dominated by aggressive, weedy grasses</i>				
2009	Fall	Seed with native forbs	Drill grass, broadcast forbs	
2010	Spring	Spray with Fluazifop	Spot spray, aminopyralid	
2010	Fall	Spray with Fluazifop	Treat berry, Spray with Fluazifop	
2010	Fall		Seed & plant matrix species	
2011	Spring	Broadcast Fluazifop, spot treat with Aminopyralid		
2011	Fall	Burn, broadcast glyphosate, drill <i>Festuca</i> , plant diversity		
2012	Spring	Plant plugs, lupine seed		
2012	Fall	Plant forbs, diversity, maintenance activities (spot spray, hand weed)		
2013	Spring	Spot spray		
2013	Fall	Burn and glyphosate, plant plugs and broadcast diversity, drill fescue, and broadcast lupine seed		
2014	Spring	Spot spray as needed		
2014	Fall	Fall mow, diversity planting (plug and seed)		
2015	Fall	Burn, broadcast Glyphosate, seed diversity		
2016	Spring	Broadcast Fluazifop two times		

¹Tank mix formulation should be site specific and generally include glyphosate + a more specific herbicide. Dicamba was used initially in combination with glyphosate as it is effective for legumes and has some residual effects. More recent applications using glyphosate + aminopyralid have had good weed control.

²Final seeding assumes that desired control of introduced species has been achieved. Final seeding may need to be delayed and treatments repeated.

Results and Discussion

Prior to restoration treatments, ground and vegetation cover at Big Spires were both reflective of a highly degraded site. In the first few years of treatments (2008 and 2009), the plant community was heavily dominated by introduced forbs and graminoids (Figure 4, Appendix A). Since 2009, there has been a marked decrease in invasive forbs after spraying with aminopyralid (Figure 4, Table 2). Continued treatments with the grass-specific Fluazifop and seeding with native species has decreased invasive graminoids cover and increased native cover so that they were basically even in 2012 (Figure 4).

In fall 2013, the site underwent numerous treatments including burning, drill seeding of *Festuca roemerii*, and broadcast seeding of a diversity mix (Table 2), and the plant community responded to those treatments occurred. Between 2013 and 2015, there was a large increase in forbs at the site, both native and introduced (Figure 4). Introduced forbs increased by roughly 85% from 2013 to 2015 (from 9% to 17%, respectively). Native forbs increased by roughly 176% from 2013 to 2015 (6 to 15%, respectively). The increase in native forbs was likely associated with seeding and plug planting that occurred after the burn. *Eriophyllum lanatum* increased greatly in recent years from 3.2% in 2013 to 14% in 2015. The continued increase in introduced forbs was most-likely associated with bare ground created after the fire. *Plantago lanceolata* increased greatly from 2013 (from 3.6% cover to 6.9% cover), this species was not found on the site prior to 2010. After an increase in introduced graminoids from 2013 to 2014, we noted a substantial decline in 2015 (Figure 4). Cover of *A. stolonifera* declined from 35.2% in 2013 to 8.4% in 2015, a 24% decrease across the site. *Festuca roemerii* was drill seeded in 2013 after the burn, and though cover initially declined in 2014, cover of native graminoids has increased greatly in 2015. Cover of *Festuca roemerii* was 57.7% in 2015.

Management Recommendations

In 2015 we saw a decline in introduced forbs and graminoids at the site, coupled with an increase in both native forbs and graminoids. We recommend continued quantitative monitoring to determine relative species' abundance. Continued treatments to target non-native grasses and forbs are recommended. The increase in native forbs and native grasses, primarily *Festuca roemerii* are promising; continued seedings of native species would help increase abundance on the site.

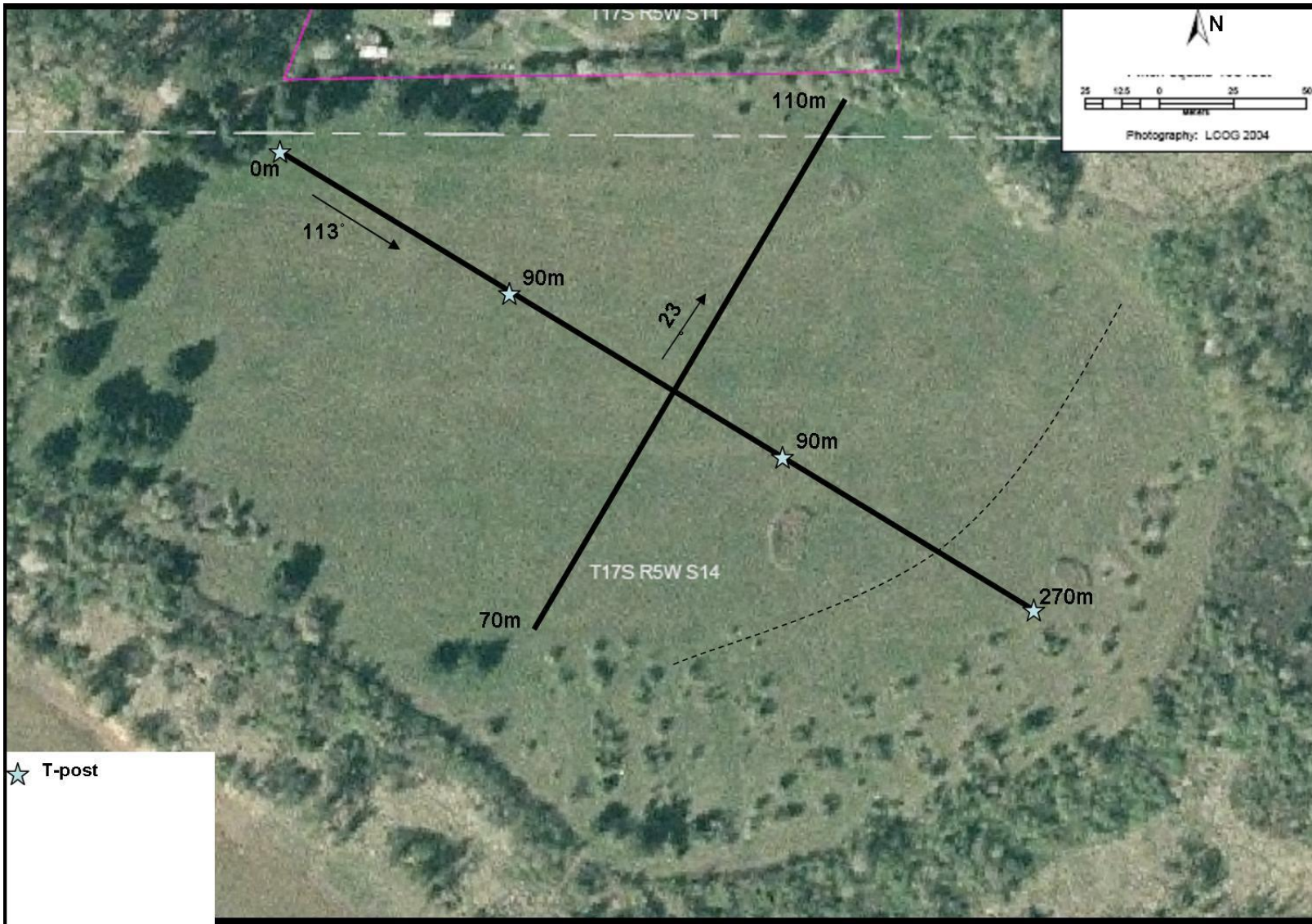


Figure 2. Big Spires upland prairie restoration site at Fern Ridge Lake. An x and y-axis were superimposed on the meadow in order to randomly selected locations for sampling plots. T-posts were placed along the x-axis every 90m.

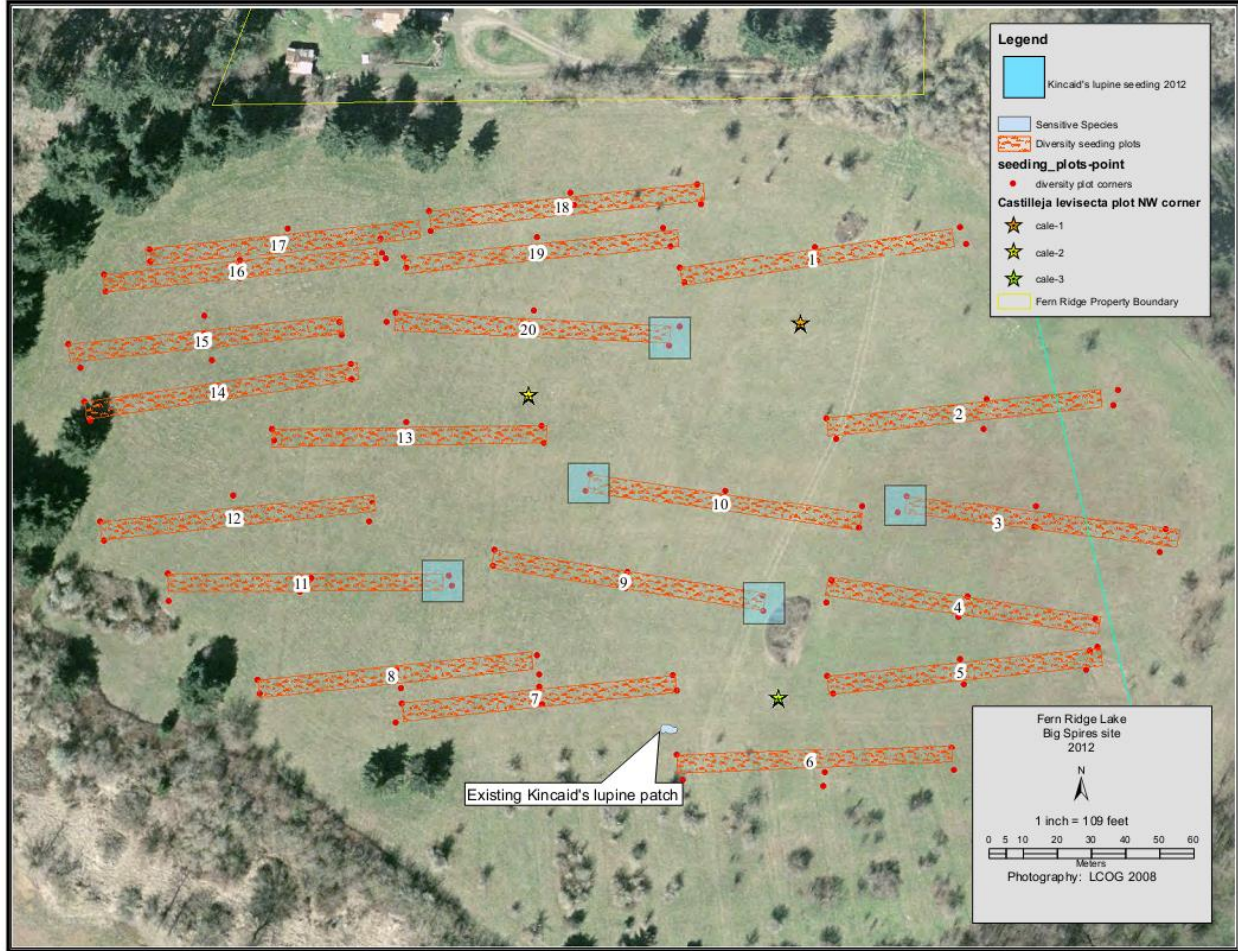


Figure 3. Location of diversity plots at Big Spires. Blue boxes indicate additional plantings of Kincaid's lupine and stars are locations of *Castilleja* plantings.

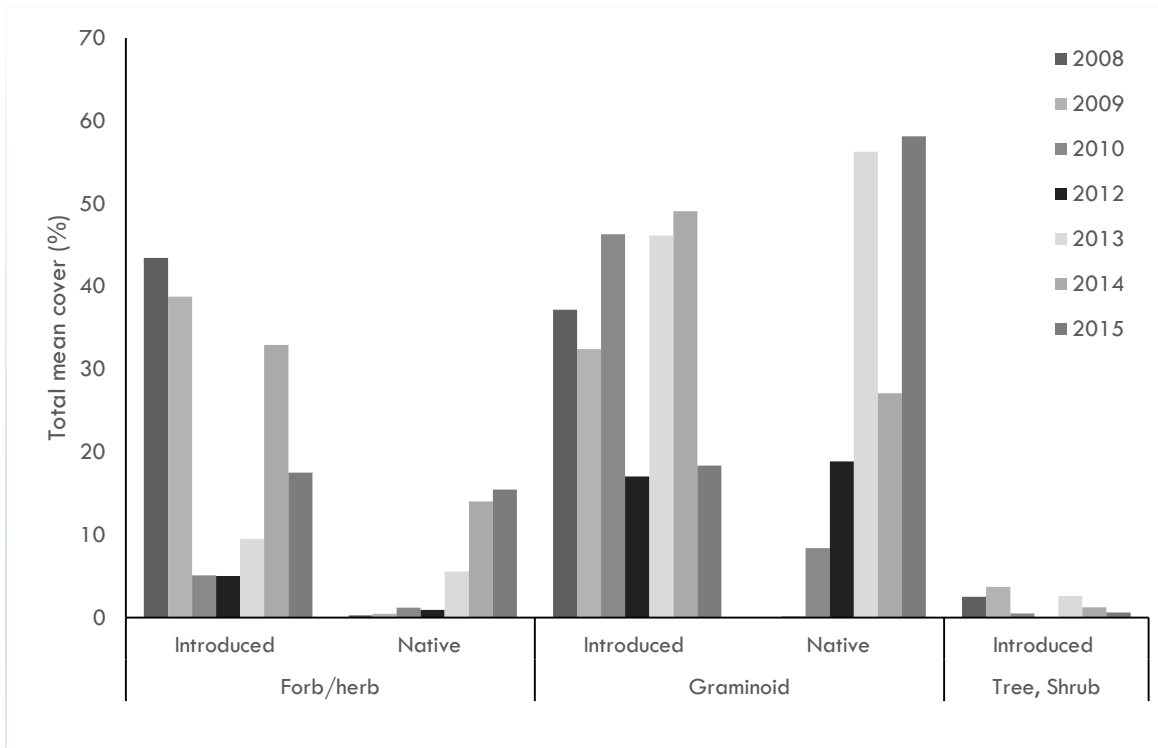


Figure 4. Cover estimates of introduced and native species at Big Spires from 2008 to 2015 (quantitative data was not collected in 2011). Estimated cover of each functional group*nativity = sum (average cover plot⁻¹ for each species in that category).

BIG SPIRES NE/SOUTH OF EAST SPIRES

Restoration treatments were initiated at Big Spires NE/South of East Spires in spring 2009 (Table 3).

Table 3. Treatment schedule for Big Spires NE/South of East Spires at Fern Ridge Lake. 2009 was the first year of restoration treatments at this site.

Year	Season	Recommendations	Treatment	Actual
2007	Fall		Wildfire	
2008	Fall		Mow	
<i>"Matrix" treatment</i>				
2009	Spring	Spray with glyphosate or tank mix ¹	Broadcast glyphosate	
2009	Fall	Burn, propane torch, hay, or mow		
2009	Fall	2 -4 weeks post-burn (or after other treatment): Glyphosate	Broadcast glyphosate	
2009	Fall/Winter	If possible, spray with glyphosate a second time		
2010	Spring	Spray with glyphosate or tank mix ¹	Broadcast glyphosate	
2010	Fall	Burn, propane torch, hay, or mow	(insufficient material for burn)	
2010	Fall	2 -4 weeks post-burn: Glyphosate	Broadcast glyphosate	
2011	Spring	Spray with herbicide (Fluazifop)		
2011	Fall	Assess, plant diversity; repeat glyphosate or other herbicide as necessary		
2012	Spring	Assess for broadcast		
2012	Fall	Drill <i>Festuca</i>		
2013	Spring	Assess for broadleaf spray		
2013	Fall	No action		
2014	Spring	Declare failure or reset		
2014	Fall	Fall mow		
2015		No action		

¹Tank mix formulation should be site specific and generally include glyphosate + a more specific herbicide. Dicamba was used initially in combination with glyphosate as it is effective for legumes and has some residual effects. More recent applications using glyphosate + aminopyralid have had good weed control.

²Final seeding assumes that desired control of introduced species has been achieved. Final seeding may need to be delayed and treatments repeated.

Monitoring

Botanical surveys were first completed at Big Spires NE in May 2009. Two axes were superimposed on an aerial photo of the meadow (Figure 5) and coordinates were randomly selected for plot placement. We placed a t-post at each end of the longest axis, which extends 90m East-West. The shorter axis is 70m long and runs perpendicular at 180°. Plots that were outside of the meadow were eliminated and replaced with another randomly selected location until 20 plots were selected. We placed a 1m² sampling frame at the top right corner at each selected sampling point and estimated the percent cover of each species and ground cover category (bare ground, rock, and moss).

In May, 2010 and 2011, we conducted qualitative surveys of the site, noting dominant vegetation and distribution and abundance of species of interest (e.g. valuable native species such as *Sidalcea* or previously dominant invasive species such as *Arrhenatherum elatius*). This site was not monitored in 2012 or 2013, but was monitored qualitatively in 2014 and 2015.

Results and Discussion

In 2009, the only year of quantitative survey, Big Spires NE was heavily dominated by introduced forbs (14%) and graminoids (67%; Figure 6, Appendix B). The dominant species were *Agrostis* spp. (introduced grass, 32.9%), *Anthoxanthum odoratum* (introduced grass, 16.5%), *Elymus glaucus* (native grass, 10.1%), *Festuca arundinacea* (introduced grass, 9.9%), and *Spiraea douglasii* (native shrub, 9.5%). With the exception of the “weedy” native forb *Galium aparine* (cover 3.8%), there were no other native species with cover >1%. Additional species observed, but not located in plots included *Sanguisorba minor*, *Toxicodendron diversilobum*, *Phalaris arundinacea*, and *Centaurea* (near the east end of the meadow).

This site was mowed in 2009, followed by a patchy herbicide treatment with glyphosate + dicamba. In September of 2009, we observed that, similar to Cherry Orchard, *P. aquilinum* was green and appeared to benefit from reduced competition following herbicide treatment. Cover of *Panicum* spp., which was not observed during our May surveys, was approximately 6% of the entire site. There were several large plants that had released seeds. Density of *Panicum* was higher closer to the lake.

In May 2010 qualitative surveys, we observed that the dominant species were *Parentucellia viscosa*, *Arrhenatherum elatius*, and *Vicia* spp. There was also a dense patch of *Myosotis discolor* in the northeast corner of the site. Although not dominant, there were several scattered *Leucanthemum vulgare* individuals. There was good control of vegetation (~ 90% bare ground) on the border with East Spires.

Despite being treated with grass-specific herbicide, in 2011 the site was dominated by non-native grasses *Anthoxanthum odoratum* and *Agrostis* sp (3% and 2% respectively). The remaining species with estimated cover greater than one percent were all non-native forb species.

Results from our qualitative surveys in 2015 suggest that the site has not changed greatly since 2014. In the 2015, dominant species included introduced grasses *Anthoxanthum odoratum* (35%), *Arrhenatherum elatius* (10%), *Dactylis glomerata* (8%), *Agrostis stolonifera* (10%), and *Holcus lanatus* (8%). The most abundant native species at the site, *F. roemerii*, covered roughly 25% which was patchy and common throughout. This presence is likely the result of drill seeding that occurred in 2012. While the plant community at this site tended to be introduced forb dominated in 2010, introduced grasses were largely dominant in 2014 and 2015. The forb community remained composed of introduced species including *Daucus carota*, *Plantago lanceolata*, and *Vicia* spp.

Management Recommendations

Given the recent increase in introduced grasses, we recommend treatments using a grass-specific herbicide such as Fluazifop. We recommend surveying the site in 2016 in order to assess the need for spot treatments of invasive species and assessment if treatments need to be repeated another year or if select species can be seeded in fall 2016.

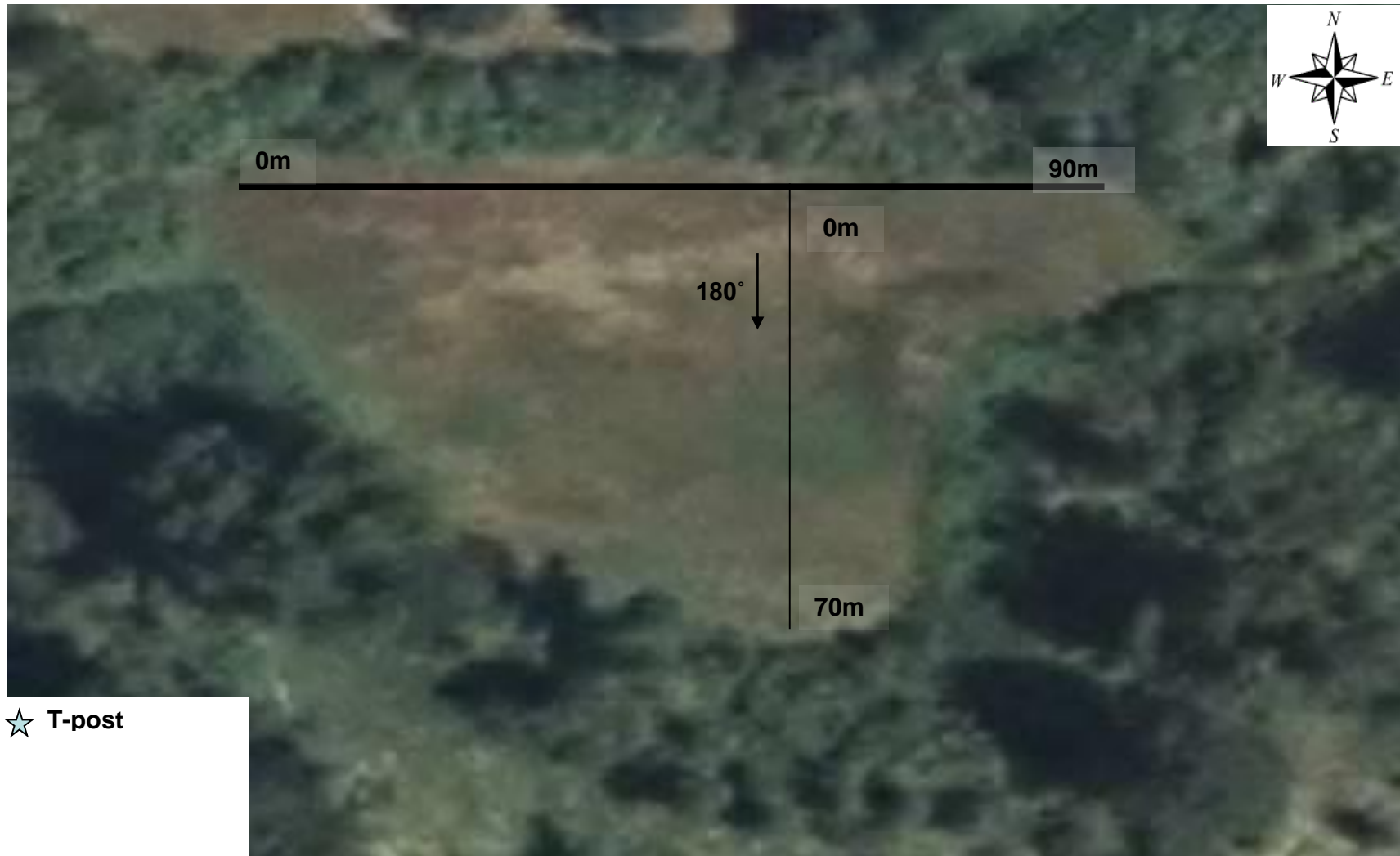


Figure 5. Big Spires NE upland prairie restoration site at Fern Ridge Lake. An x and y-axis were superimposed on the meadow in order to randomly selected locations for sampling plots. T-posts were placed on either end of the 90m axis running east-west.

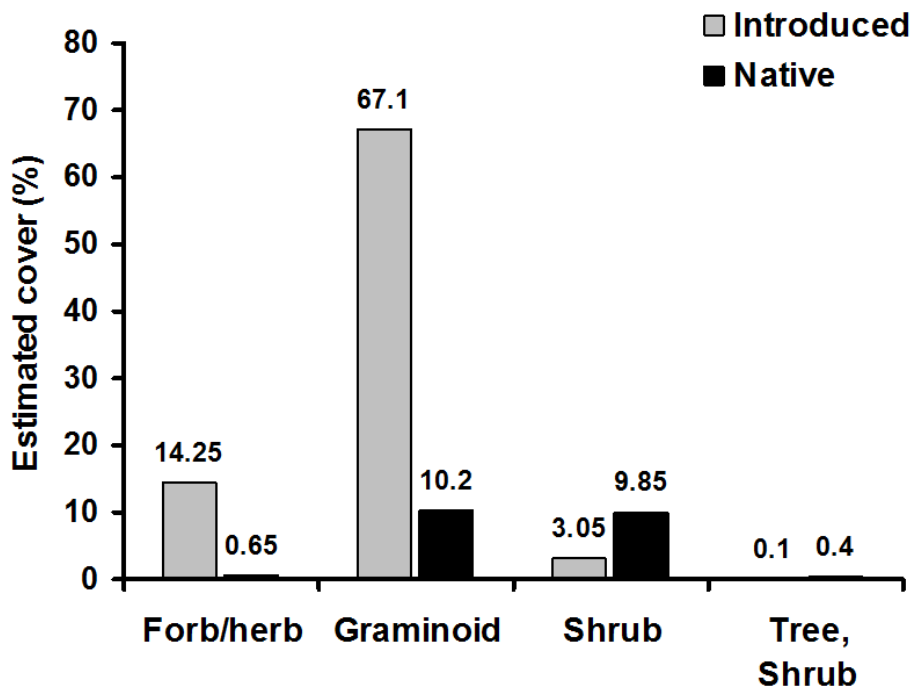


Figure 6. 2009 cover estimates of introduced and native species at Big Spires NE. Bars represent the total cover of all species in each growth form. Estimated cover of each functional group*nativity = sum(average cover plot⁻¹ for each species in that category).

CHERRY ORCHARD

Restoration treatments and botanical surveys were initiated at Cherry Orchard spring 2009 (Table 4).

Monitoring

For botanical surveys at Cherry Orchard in 2009, two axes were superimposed on an aerial photo of the meadow (Figure 7) and coordinates were randomly selected for plot placement. We placed a t-post at each end of the longest axis, which extended 228m North-South. The shorter axis was 225m long and ran perpendicular to the long axis. Plots that were outside of the meadow were eliminated and replaced with another randomly selected location until 31 plots were selected. We placed a 1m² sampling frame at the top right corner at each selected sampling point and estimated the percent cover of each species and ground cover category (bare ground, rock, and moss). Quantitative monitoring was conducted in 2014 and 2015

In growing seasons 2010 to 2013, we conducted qualitative surveys of the site, noting dominant vegetation and distribution and abundance of species of interest (e.g. valuable native species such as *Sidalcea* or previously dominant invasive species such as *Arrhenatherum elatius*).

Table 4. Treatment schedule for Cherry Orchard at Fern Ridge Lake. 2009 is the first year of restoration treatments at this site.

Year	Season	Treatment	
		Original Recommendations	Actual
2008	Fall		Mow
<i>“Matrix” treatment</i>			
2009	Spring	Spray with glyphosate or tank mix ¹	Broadcast glyphosate
2009	Fall	Burn, propane torch, hay, or mow	
2009	Fall	2 -4 weeks post-burn (or after other treatment): Glyphosate	Broadcast glyphosate
2009	Fall/Winter	If possible, spray with glyphosate a second time	
2010	Spring	Spray with glyphosate or tank mix ¹	Broadcast glyphosate
2010	Fall	Burn, propane torch, hay, or mow	Burn
2010	Fall	2 -4 weeks post-burn: Glyphosate	Broadcast glyphosate
2011	Spring	Broadcast glyphosate & aminopyralid	
2011	Fall	Assess for broadcast, drill for seed production	
2012	Spring	Assess for broadcast	
2012	Fall	Drill <i>Festuca</i>	
2013	Spring	Broadcast Fluazifop	
2013	Fall	Assess for third drill fescue; burn; assess for diversity planting; plugs	
2014	Spring	Spot-spray <i>H. lanatus</i> , assess for Fluazifop and/or chaparral; possibly hand weed in spots and patches	

2014	Fall	Fall mow, diversity planting
2015	Fall	Burn, broadcast glyphosate, seed diversity
2016	Spring	broadcast Fluazifop two times

¹Tank mix formulation should be site specific and generally include glyphosate + a more specific herbicide. Dicamba was used initially in combination with glyphosate as it is effective for legumes and has some residual effects. More recent applications using glyphosate + aminopyralid have had good weed control.

²Final seeding assumes that desired control of introduced species has been achieved. Final seeding may need to be delayed and treatments repeated.



Figure 7. Cherry Orchard upland prairie restoration site at Fern Ridge Lake. An x and y-axis were superimposed on the meadow in order to randomly selected locations for sampling plots. T-posts were placed at 0, 90, 180, and 228m on axis running east-west.

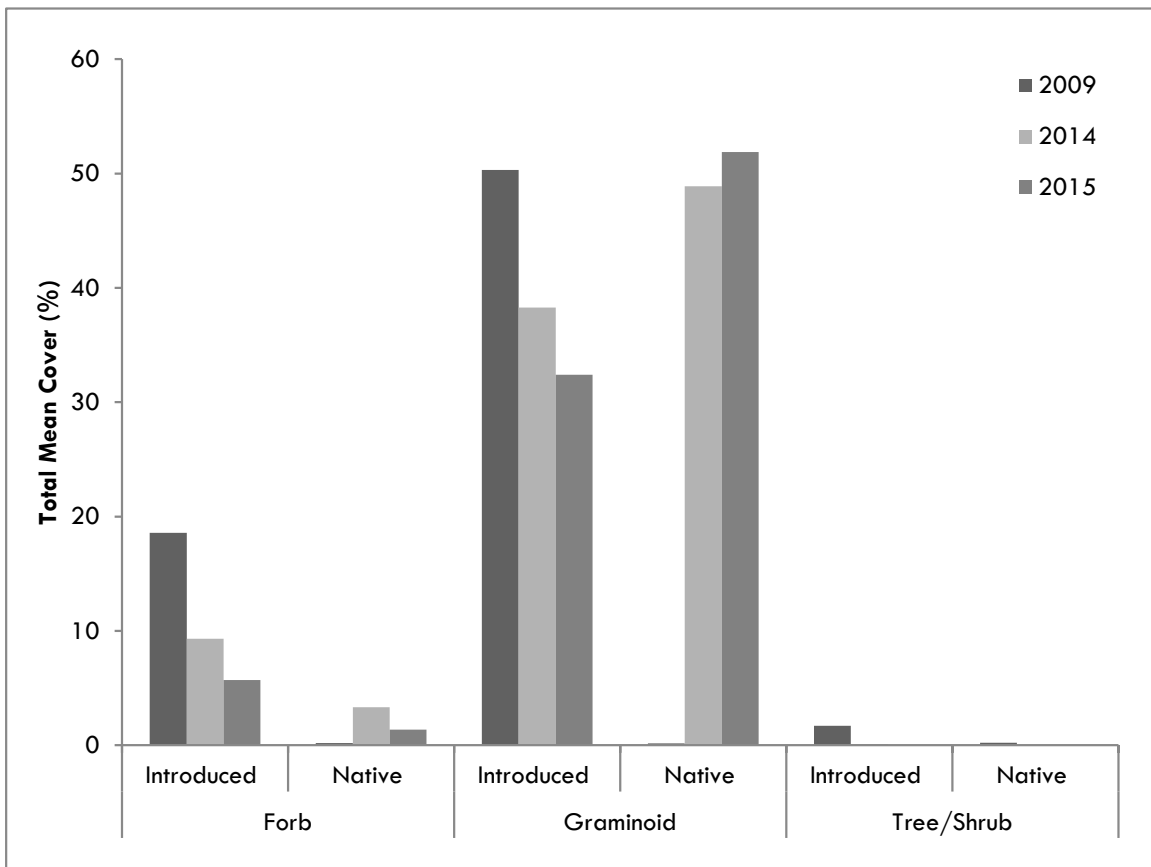


Figure 8. Cover estimates of introduced and native species at Cherry Orchard 2009, 2014, and 2015. Bars represent the total cover of all species in each growth form. Estimated cover of each functional group*nativity = sum(average cover plot⁻¹ for each species in that category).

Results and Discussion

The plant community at Cherry Orchard has changed greatly between 2009 and 2015, from an introduced-species dominated community to one with much higher native species composition (Figure 8). In May 2009, the first year of quantitative data, Cherry Orchard was dominated by introduced graminoid (50.3%) and forb (12.5%) species (Figure 8, Figure 9). The site was burned in 2013 and drilled with *F. roemerii* along with fall mowing and diversity planting in 2014.

In 2015, our quantitative monitoring indicated that the site has continued to improve. There was an increase in native graminoids, including that of *Festuca roemerii* which was not present in 2009. *Festuca roemerii* averaged 52% of cover in 2015 and was the dominant

species (seen with the purple seed heads, Figure 9B). There was also a decline in introduced graminoids from 2009 to 2015 (Figure 13). Cover estimates of introduced and native species in untreated and treated increments at North Eaton in 2010 and 2013. Bars represent the total cover of all species in each growth form. Estimated cover of each functional group*nativity = sum(average cover plot⁻¹ for each species in that category). In 2014 and 2015 *Festuca arundinacea* was no longer present on the site, while it composed 14.9% cover in 2009. *Arrhenatherum elatius* declined from 24.9% in 2009 to 3.2% in 2015. Despite these improvements, *Agrostis stolonifera*, an introduced graminoid, increased over the time of the study from 3.6% cover in 2009 to 31.3% in 2014; cover of this introduced graminoid declined slightly in 2015, but still remains at relatively high levels (20%). While native forbs increased from 2009 to 2014, they declined again in 2015. Introduced forbs continued to decline between 2009 and 2015 (Figure 8).

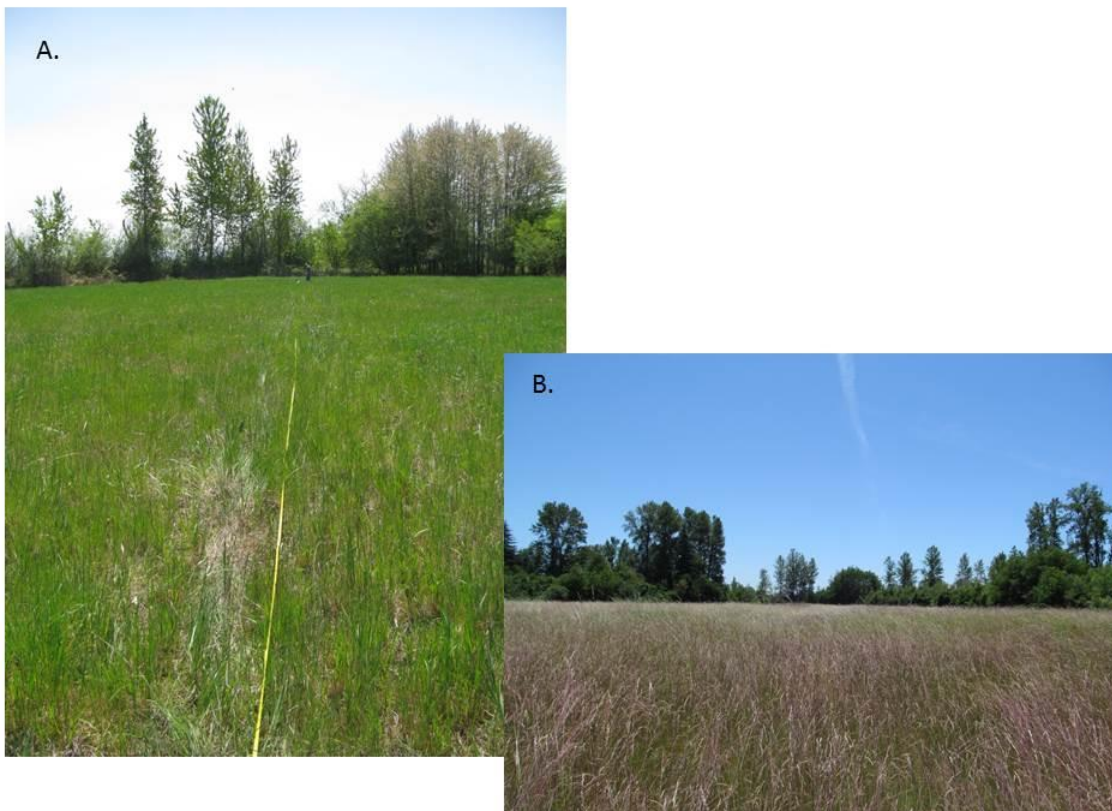


Figure 9. Cherry Orchard site in (a) April 2009 prior to herbicide treatments and (b) in June 2014.

Management Recommendations

We recommend continued surveys in 2016 in order to assess need for spot treatments of invasive species. Future efforts focused on control of *Agrostis* and other introduced graminoids should be considered, while not impacting cover of native graminoids. Likewise, treatments effective at targeting introduced forbs should be considered.

SOUTH EATON

South Eaton was split along a north/south axis into 3 treatment sections (Table 5). 2007 was the first year of restoration treatments in the central 3.3 acres. Treatments were initiated in fall 2009 for the east 2.4 acres and spring 2010 in the west 3 acres.

Table 5. Treatment schedule for South Eaton at Fern Ridge Lake. 2007 was the first year of restoration treatments in the central 3.3 acres. Treatments were initiated in fall 2009 the east 2.4 acres and spring 2010 in the west 3 acres.

Year	Season	Treatments
South Eaton Central		
2007	Spring	Broadcast glyphosate & dicamba ¹
2007	Fall	Mow, broadcast glyphosate & dicamba, dill grass
2008	Fall	Mow
2009	Spring	Handweed <i>Arrhenatherum elatius</i>
2009	Fall	mow
2009	Fall	Broadcast aminopyralid, treat <i>Centaurea pratensis</i>
2010	Spring	Broadcast aminopyralid, treat <i>Centaurea pratensis</i> , <i>Daucus carota</i>
2010	Fall	
2011	Spring	Broadcast aminopyralid & Fluazifop
2011	Fall	Assess for broadcast, hay, drill <i>Festuca</i>
2012	Spring	Assess for broadcast
2012	Fall	Drill <i>Festuca</i>
2013	Spring	Broadcast Fluazifop; assess for broadleaf spray
2013	Fall	Burn and glyphosate; drill <i>Festuca</i> ; assess for diversity planting (no planting)
2014	Spring	Asses for Fluazifop and/or Chaparral
2014	Fall	Fall mow
2015	Fall	Burn, broadcast glyphosate,
2016	Spring	broadcast Fluazifop two times, broadcast Aminopyralid+Glyphosate
South Eaton East		
2009	Fall	Mow, Broadcast glyphosate & dicamba
2010	Spring	Broadcast glyphosate & aminopyralid
2010	Fall	Broadcast spray
2011	Spring	Broadcast glyphosate & aminopyralid
2011	Fall	Assess for broadcast, drill <i>Festuca</i>
2012	Spring	Assess for broadcast
2012	Fall	Drill <i>Festuca</i>
2013	Spring	Broadcast Fluazifop; assess for broadleaf spray
2013	Fall	Burn and glyphosate; drill <i>Festuca</i> ; assess for diversity planting

2014	Spring	Asses for Fluazifop and/or Chaparral or hand-weeding in spots and patches
2014	Fall	Fall mow, diversity planting
2015	Fall	Burn, broadcast glyphosate, seed diversity
2016	Spring	Broadcast fluazifop 2x
South Eaton west		
2010	Spring	Broadcast glyphosate, treat <i>Centaurea pratensis</i>
2011	Fall	Broadcast spray; assess for milestone tank mix; drill fescue
2012	Spring	Assess for broadcast
2012	Fall	Drill <i>Festuca</i>
2013	Spring	Broadcast Fluazifop (except east patch); assess for broadleaf spray
2013	Fall	Burn and glyphosate; drill <i>Festuca</i> ; lupine seed, diversity planting
2014	Spring	Assess for Fluazifop and/or Chaparral or hand-weeding in spots and patches
2014	Fall	Fall mow
2015	Fall	Burn, broadcast glyphosate, seed diversity
2016	Spring	Broadcast fluazifop 2x

¹Dicamba is effective against legumes and has some residual effects.

²Final seeding assumes that desired control of introduced species has been achieved. Final seeding may need to be delayed and treatments repeated.

Monitoring

We initiated botanical surveys at South Eaton in May 2009. Two axes were superimposed on an aerial photo of the meadow (Figure 10) and coordinates were randomly selected for plot placement. We placed a t-post at each end of the longest axis, which extended 242 m north-south. The shorter axis was 154m long and ran perpendicular to the long axis. Plots that were outside of the meadow were eliminated and replaced with another randomly selected location until 39 plots were selected. We placed a 1x1m sampling frame at the top right corner at each selected sampling point and estimated the percent cover of each species and ground cover category (bare ground, rock, and moss). When conducting our surveys, we noted which plots were in the central (untreated, n = 17) or east or west (treated, n = 22) segments.

In spring from 2010 to 2014, we conducted qualitative surveys of the site, noting dominant vegetation and distribution and abundance of species of interest (e.g. native species such as *Sidalcea* or previously dominant invasive species such as *Arrhenatherum elatius*). We also systematically surveyed the entire site for the presence of *Centaurea*.

In 2015 we monitored quantitatively, utilizing a similar transect layout. We broke the site up into the three treatment sections (west, central, and east), and randomly selected points to have 10 plots per section (Figure 10). Percent cover of all species was visually estimated similar to in previous years.



Figure 10. South Eaton upland prairie restoration site at Fern Ridge Lake, broken into approximate sections for management. West, east, and central sections were monitored separately in 2015. An x and y-axis were superimposed on the meadow in order to randomly selected locations for sampling plots, monitoring 10 plots per section.

Results and Discussion

In May 2009, the only year of quantitative survey, the east and west increments (treated) of South Eaton were dominated by introduced graminoid (59.6%) and forb (36.1%) species (Figure 11, Appendix D). The dominant species were *Agrostis* spp. (22.2%), *Anthoxanthum odoratum* (20.3%), *Hypochaeris radicata* (15.8%), *Vicia* spp. (10.5%), *Arrhenatherum elatius* (8.9%), and the native *Elymus glaucus* (8.7%). *Fragaria virginiana* was the only other native species with cover >1% (1.2%).

In the central increment of South Eaton (untreated), cover of native graminoids was equal that of introduced forbs (28%). However, the total cover of introduced forbs was 80%, while there were almost no native forbs. These forbs appeared to be located mainly between the rows into which the native grasses had been sown. The dominant species in the treated increment were *Vicia* spp. (introduced forb, 33%), *Hypochaeris radicata* (introduced forb, 26.9%), *Bromus carinatus* (native grass, 19.8%), *Daucus carota* (introduced forb, 9.3%), *Agrostis* spp. (introduced grass, 7.5%), and *Elymus glaucus*

(native grass, 7.5%). *Lupinus oreganus* occurred in both the west and east sections. The native species *Sidalcea campestris* and *Iris tenax* are also abundant near the eastern edge of the site. However, these species were not detected in our surveys. Although it was not located in our plots, in 2009 we observed two patches of *Centaurea* on the north end of the site. In 2010, we counted 31 *C. pratensis* rosettes and 51 bolted plants in the north end of the west section, and approximately 10 individuals in the north end of the east section.

In 2014 we conducted qualitative monitoring, and the center section was dominated by introduced grasses and forbs, including *Agrostis stolonifera*, *Hypericum perforatum*, *Hypochaeris radicata*, *Plantago lanceolata*, and *Sherardia arvensis*. The native grass, *Festuca roemerii* had increased in the center section since 2013 due to the recent seeding. There was a very large patch of non-native forbs including *Cerastium glomeratum*, *Sherardia arvensis*, and *Hypericum perforatum* at the southern end of the center section. The west section was dominated greatly by the seeded *F. roemerii* along with the introduced grass *A. stolonifera*. Rows were visible from the *F. roemerii* seeding. There were areas that had been sprayed with herbicide that had lower total cover and higher cover of forbs including *Plantago lanceolata* and *Sherardia arvensis*. Also abundant in this section were the introduced forbs *H. perforatum*, *H. radicata*, *P. lanceolata*, and *S. arvensis* and the introduced grass *A. odoratum*. The east section was extremely similar to the west section in plant community composition, dominated by *F. roemerii* with patchy forbs and *Agrostis*. Native forbs were present in trace amounts, including *Eriophyllum lanatum*, *Iris tenax*, and *Lupinus oreganus*. In 2014, *C. pratensis* was present in trace amounts in the east and west sections, but was much more abundant and patchy in the center section composing roughly 5% cover.

We monitored the west, central, and east sections separately in 2015. In 2009 quantitative comparisons combined the east and west sections together, and the central section separately. While these areas were monitored differently, we can make some comparisons. As in previous years, the east and west sections were similar in 2015 (Figure 11), being dominated by native grasses, followed by high cover of introduced grasses and a moderate amount of introduced forbs. In 2015, the west section was dominated by *Festuca roemerii* (53.6%), along with non-native grasses *Agrostis* sp. (35.2%). Other species with high abundance included *Plantago lanceolata* (4.2%) and *Hypochaeris radicata* (8.5%). The east section had similar abundances with *F. roemerii* dominating (44.8%) followed by *Agrostis* sp. (28.9%). *Hypochaeris radicata* was particularly abundant in this section composing 20.3% cover. These changes indicate that while there remains high abundance of introduced grasses in these sections, cover of native graminoids has increased greatly. Likewise, cover of introduced forbs has decreased greatly since 2009.

The central section differs in community composition from the east and west sections. Though it has received treatments over the years, plant community composition remains similar to what was present in 2009, dominated by introduced forbs and grasses (Figure 11). The central section was dominated by *Agrostis* sp. (14.6%) and *Aira caryophyllaea*

(13.7%), along with introduced forbs *Hypochaeris radicata* (26.1%) and *Plantago lanceolata* (14.9%).

Management Recommendations

At South Eaton, we recommend following the matrix treatments outlined above (Table 1). *Centaurea* should be spot-sprayed or hand-pulled. A small trail through the hedgerow between North and South Eaton ends at the *Centaurea* patch in the west segment of South Eaton and may serve as a dispersal corridor for *Centaurea*. As the longevity of *Centaurea* seeds in the soil can be >6 years (Callihan et al. 1993; Davis et al. 1993), monitoring should continue for multiple years after all individuals have been eradicated.

South Eaton was burned in the fall 2013, followed by seeding of *F. roemerii* and other natives. While community composition differed between the central section and the east and west sections in 2015, introduced grasses and forbs continued to have high cover across the entire site and should be targeting for treatment. The east and west sections of the site did have high cover of native grasses, so selecting a grass-specific herbicide (e.g. fusilade) that would not affect fine-leaved grasses such as *F. roemerii* would be ideal. Introduced forbs were particularly abundant in the central section. Following these treatments, seeding with native grasses and forbs would be ideal, particularly in the central section where native composition is low.

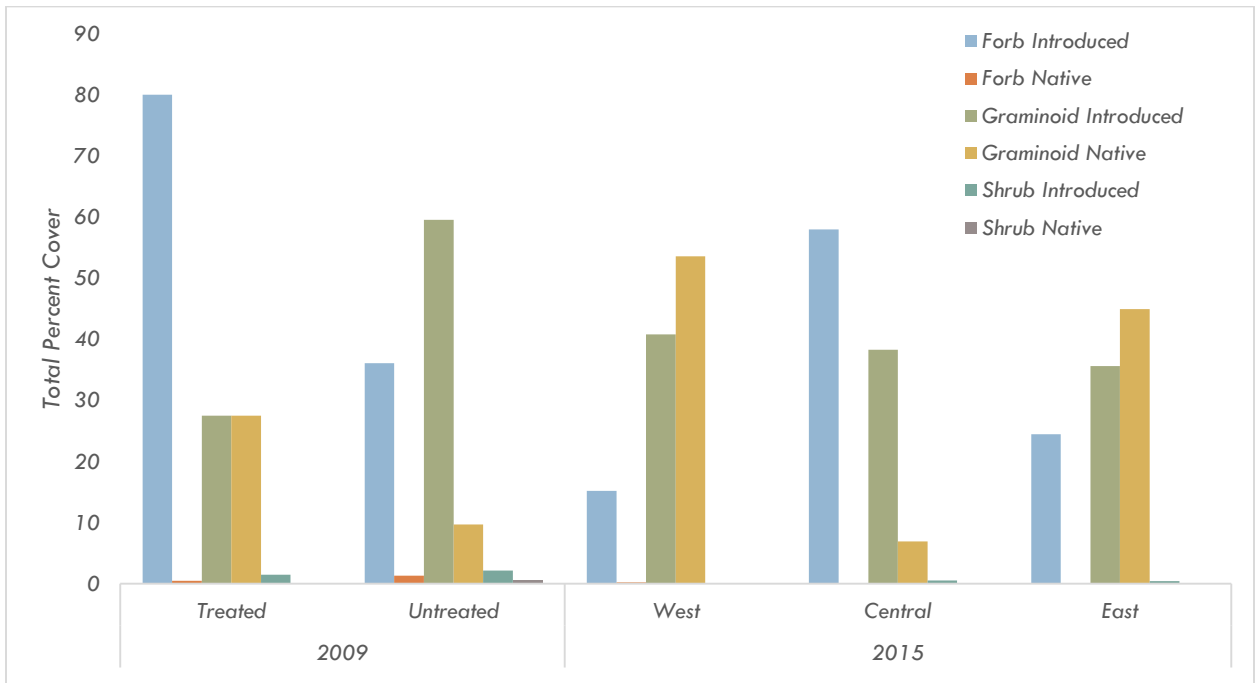


Figure 11. Cover estimates of introduced and native species in untreated and treated increments at South Eaton in 2009, and in the three monitoring areas in 2015. Bars represent the total cover of all species in each growth form. Estimated cover of each functional group*nativity = $\text{sum}(\text{average cover plot}^{-1} \text{ for each species in that category})$.

NORTH EATON

North Eaton has been dominated by *Anthoxanthum odoratum*. Although this introduced grass is suppressing native forbs and grasses, it is also suppressing other introduced species. This site is occupied by three large patches of *Lupinus*. Treatments were initiated in spring 2010 (Table 6). Prior to this, the site was mowed in the spring and fall of each year.

Table 6. Treatment schedule for North Eaton at Fern Ridge Lake. 2010 was the first year of restoration treatments at this site. Prior to 2010, the site was managed with spring and fall mowing.

Year	Season	Treatments
2010	Spring	Broadcast glyphosate + aminopyralid, treat <i>Centaurea pratensis</i>
2010	Fall	Broadcast glyphosate + aminopyralid
2011	Spring	Broadcast glyphosate + aminopyralid, assess for mowing
2011	Fall	Assess for broadcast, drill <i>Festuca</i>
2012	Spring	Broadcast Chaparral
2012	Fall	Drill <i>Festuca</i>
2013	Spring	Broadcast Fluazifop; assess for broadleaf spray
2013	Fall	assess for diversity planting (did not plant)
2014	Spring	Asses for Fluazifop and/or Chaparral or hand-weeding in spots and patches
2014	Fall	Fall mow
2015		No Action
2016	Spring	Broadcast Fluazifop two times

Monitoring

We initiated botanical surveys at North Eaton in May 2010. Two axes were superimposed on an aerial photo of the meadow (Figure 12) and coordinates were randomly selected for plot placement. We placed 1m aluminum conduit posts at 0, 100, and 200 along the longest axis, which extends east-west. Plots that were outside of the meadow were eliminated and replaced with another randomly selected location until 30 plots were selected. We placed a 1x1m sampling frame at the top right corner at each selected sampling point and estimated the percent cover of each species and ground cover category (bare ground, rock, and moss). In 2013, we again quantitatively surveyed the vegetation as described.

In spring 2011, 2012, 2014 and 2015, we conducted qualitative surveys of the site, noting dominant vegetation and distribution and abundance of species of interest (e.g.

native species such as *Sidalcea* or previously dominant invasive species such as *Arrhenatherum elatius*). We also systematically surveyed the entire site for the presence of *Centaurea*.

Results and Discussion

In May 2010 North Eaton was dominated by introduced graminoid and forb species (Figure 13, Appendix E). The dominant species were *Anthoxanthum odoratum* (introduced grass, 29.9%), *Hypochaeris radicata* (introduced forb, 7.8%), and *Agrostis stolonifera* (introduced grass, 7.2%). The native species with the highest cover were *Festuca roemerii* (grass, 2.5%), *Quercus garryana* (tree, 1.3%), and *Elymus glaucus* (1.3%). Although the average cover was low (1.3%), we observed numerous *Cytisus scoparius* seedlings throughout the site.

Following two years of herbicide treatment and *Festuca* seeding (Table 6), in 2013 the dominant plants at the site were a mix of native and invasive grasses. Native *Festuca roemerii*, drilled at the site in fall 2012, was the most dominant at 41.8% cover. The introduced grasses, *Anthoxanthum odoratum* and *Agrostis stolonifera*, were dominant at this site (21.6% and 19.3% respectively). While the introduced graminoids have remained relatively stable since 2010 (Figure 13), the addition of native *Festuca* increased the native graminoids cover from about 5% to over 40%. Treatments at this site have also successfully decreased the cover of non-native forbs while keeping the native forb cover stable, though low (Figure 13). *Lupinus oreganus* cover was detected at 0.4% and, while not detected in our survey, *Sidalcea campestris* was present at the site.

Monitoring in 2015 was qualitative, but shows similar trends to quantitative monitoring in 2013 and 2014 qualitative monitoring. The site was mostly graminoid dominated with very high cover of *Festuca roemerii*, composing roughly 45% cover. In 2014 and 2015, *A. odoratum* remained similar to values seen in 2013 and was interspaced within the *F. roemerii*. *Agrostis stolonifera*, has remained similar to values seen in 2013, covering roughly 20% in 2015; this species was very patchy but abundant. *Arrhenatherum elatius* was also patchy but covered roughly 8% in 2015. Forbs were patchy and were primarily introduced including *H. perforatum* (2%), *H. radicata* (4%), and *P. lanceolata* (5%). *Cytisus scoparius* was present in patches in the northeast and western corners covering roughly 5%. *Lupinus oreganus* was present and abundant in the west-center in an area that was recently treated with herbicide.

Management Recommendations

We recommend continued surveys at the site in 2016 to detect post-treatment changes in community composition. At other sites, we have observed a strong increase in cover of sub-dominant invasive species (e.g. *Agrostis* and *Daucus*) after successful treatment of dominant invasive grasses. Treatments targeting *Cytisus* will be necessary to treat patches in the northeast and western corners of the site.



Figure 12. North Eaton upland prairie restoration site at Fern Ridge Lake. An x and y-axis were superimposed on the meadow in order to randomly selected locations for sampling plots. T-posts were placed at 0, 100, and 200m on an axis running east-west. The small diamonds and coordinates represent the locations of each randomly placed sampling plot.

North Eaton

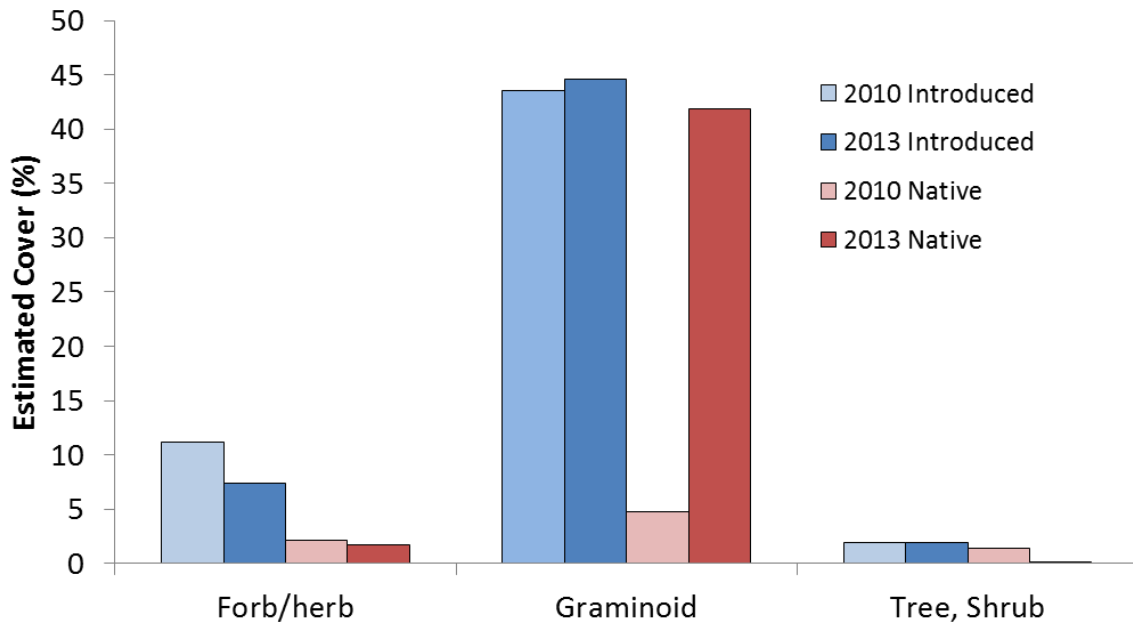


Figure 13. Cover estimates of introduced and native species in untreated and treated increments at North Eaton in 2010 and 2013. Bars represent the total cover of all species in each growth form. Estimated cover of each functional group*nativity = sum(average cover plot⁻¹ for each species in that category). North Eaton was monitored qualitatively in 2012, 2014, and 2015.

SOUTH GREEN OAKS

Although dominated by invasive species, South Green Oaks supports several important native species, including *Lupinus oreganus*, *Eriophyllum lanatum*, and *Brodiaea* spp. This site has been managed with spring and fall mowing. In spring 2009, *Centaurea pratensis* was treated with herbicide (Table 7). Broad scale treatments were initiated in spring 2010.

Table 7. Treatment schedule for South Green Oaks at Fern Ridge Lake. 2009 was the first year of restoration treatments at this site. Prior to 2009, the site was managed with spring and fall mowing.

Year	Season	Treatments
2009	Spring	Treat <i>Centaurea pratensis</i>
2010	Spring	Broadcast glyphosate, treat <i>Centaurea pratensis</i> ,
2010	Fall	[note: nothing green at the time]
2011	Spring	Broadcast glyphosate and aminopyralid
2011	Fall	Assess for broadcast, drill <i>Festuca</i>
2012	Spring	None
2012	Fall	None
2013	Spring	None
2013	Fall	None
2014	Spring	Broadcast Fluazifop
2014	Fall	Prescribed fire
2015		None

Monitoring

We initiated botanical surveys at South Green Oaks in May 2010. Two axes were superimposed on an aerial photo of the meadow (Figure 14) and coordinates were randomly selected for plot placement. We placed 1m aluminum conduit posts at 0, 100, and 169 along the longest axis, which extends east-west. Plots that were outside of the meadow were eliminated and replaced with another randomly selected location until 30 plots were selected. We placed a 1x1m sampling frame at the top right corner at each selected sampling point and estimated the percent cover of each species and ground cover category (bare ground, rock, and moss). Quantitative monitoring was repeated in 2015.

In June 2010, we systematically surveyed the entire site for the presence of the invasive forb, *Centaurea pratensis* (meadow knapweed). No surveys were conducted in 2012. In 2013 and 2014 we conducted qualitative surveys of the vegetation at South Green Oaks.

Results and Discussion

In 2010, the only year of quantitative survey, there were four times the number of introduced forbs/herbs as natives, and twice as many introduced graminoids as natives. Invasive species also had much higher cover than native species (Figure 15). With the exception of the native tree, *Alnus rubra*, which was the fourth most common (5.4%), the 12 most common species were introduced (Appendix F). These included *Hypochaeris radicata* (19.5%), *Anthoxanthum odoratum* (13.4%), *Agrostis* sp. (10.8%), *Aira caryophyllea* (5.0%), *Vulpia* sp.(3.3%), *Daucus carota* (1.3%), and *Bromus hordeaceus* (1.0%). After *Alnus*, the most common native species were the grasses, *Danthonia californica* (0.4%) and *Bromus carinatus* (0.3%). In June 2010, we counted 92 *C. pratensis* rosettes and 21 bolting plants.

In 2014 (qualitative monitoring), the site was dominated by the non-native graminoids species *Anthoxanthum odoratum* and *Agrostis stolonifera*. *Danthonia californica*, a native grass, was common across the site. We saw an increase in introduced forbs including *Daucus carota*, *Plantago lanceolata*, and *Hypochaeris radicata* from 2010 to 2014. *H. radicata* was widespread and abundant, particularly as seedlings. There was low cover of native forbs at the site. *Lupinus oregonus* was present in 2014 in a large patch in the center of the site. There were several patches of *Centaurea* in South Green Oaks (Figure 14).

There was a prescribed fire at the site in the fall of 2014. In 2015, we noted changes in plant community composition from 2010 values. Since 2010, cover of introduced forbs has increased greatly at the site (Figure 15, Appendix F. Average cover of all species observed in monitoring plots at South Green Oaks in 2010 and 2015. Dominant introduced forbs include *Daucus carota* (18.5%), *Hypochaeris radicata* (44.9%), and *Sherardia arvensis* (4.2%). Native forb cover increased slightly between 2010 and 2015. Cover of *Lupinus oregonus* from remained similar from 2010 to 2015 (0.1 and 0.2%, respectively). We observed a slight increase in introduced graminoids at the site (Figure 15). Among those, *Agrostis* sp. (11.2%), *Anthoxanthum odoratum* (8.9%), and *Bromus hordeaceus* (5.6%) dominated. Cover by *Rubus armeniacus* decreased slightly from 2010 to 2015 (0.6 to 0.3%, respectively).

Management Recommendations

After the burn which occurred in the fall of 2014, the site has moved toward an introduced forb-dominated composition. Herbicides targeting invasive forbs, particularly in areas that would not impact *Lupinus oregonus*, would be recommended. Additional herbicide treatments should be followed by heavy seeding with native species, potentially one year of a native “cover crop” that could provide competition for reinvading invasive species, but that we would be willing to sacrifice with future herbicide treatments. Despite previous spot-spraying treatments for *C. pratensis*, we counted over 100 individuals dispersed throughout the site in 2010; this species was still present in 2015.

We recommend repeating surveys at this site in 2016.

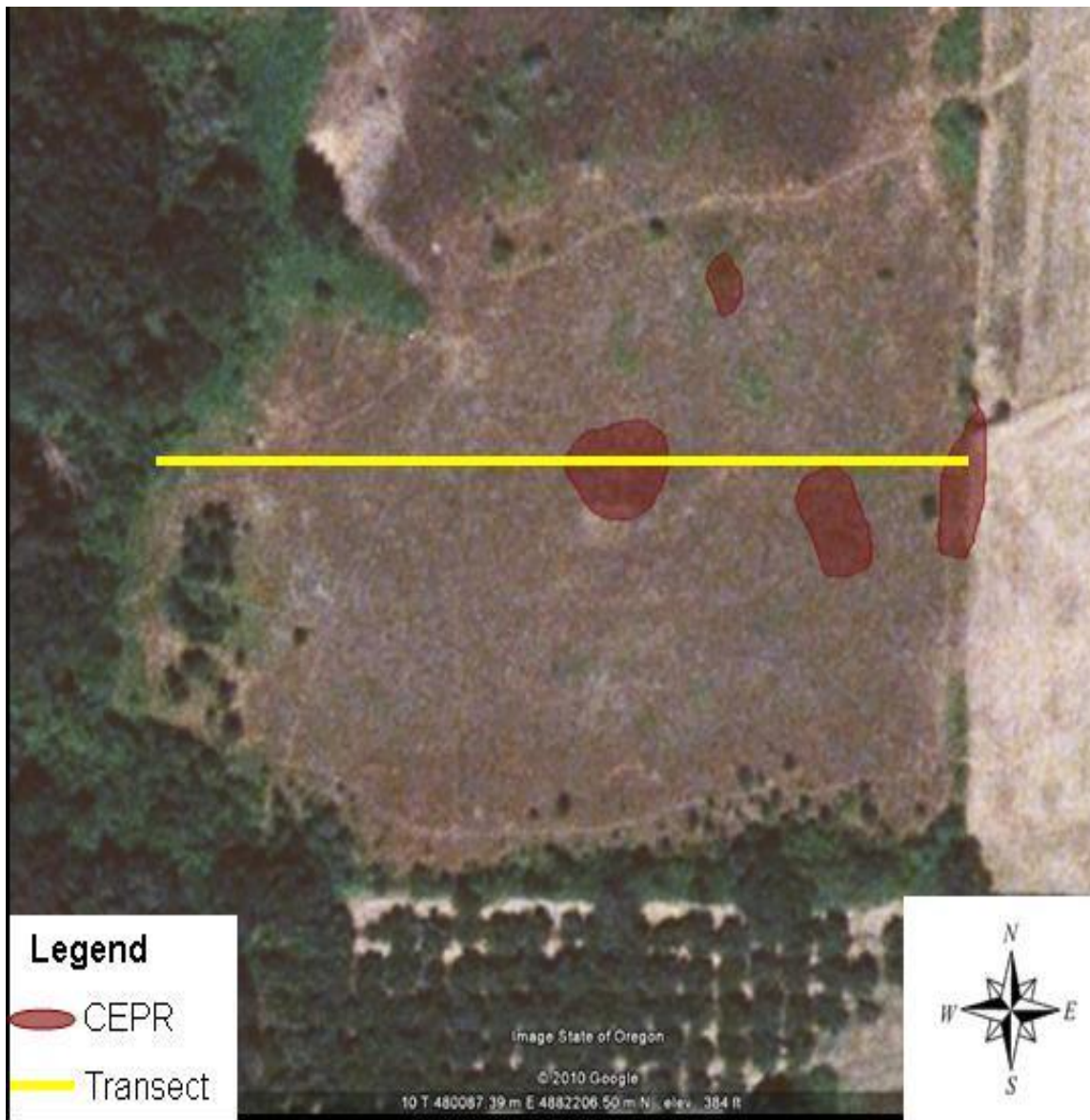


Figure 14. South Green Oaks upland prairie restoration site at Fern Ridge Lake. *Centaurea pratensis* was found in four patches within the site. T-posts were placed at 0 (East end), 100, and 169m on an axis running east-west. An x and y-axis were superimposed on the meadow in order to randomly selected locations for sampling

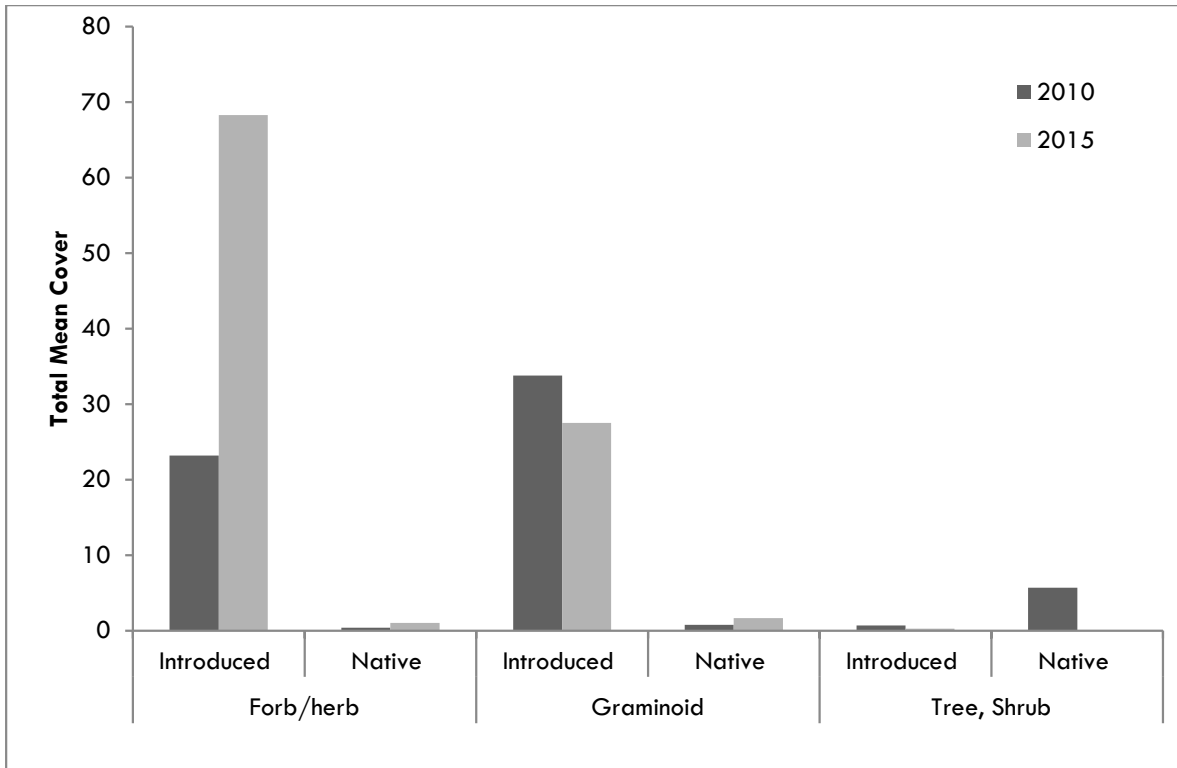


Figure 15. Total mean cover of introduced and native species in at South Green Oaks in 2010 and 2015. Bars represent the sum of the average cover of species in each growth form. Estimated cover of each functional group*nativity = sum(average cover plot⁻¹ for each species in that category).

WEST SHORE

Monitoring began in 2010 with treatments commencing in 2011 (Table 8). Prior to 2010, management at this site included spring and fall mowing.

Table 8. Treatment schedule for West Shore at Fern Ridge Lake. 2011 will be the first year of restoration treatments at this site. Prior to 2011, the site was managed with spring and fall mowing.

Year	Season	Treatments
2011	Spring	Broadcast Fluazifop
2011	Fall	Assess experiments
2012	Spring	None
2012	Fall	Mow
2013	Spring	Broadcast Fluazifop except east patch; hand weeding
2013	Fall	Lupine seeds
2014	Spring	Experimental and broadcast Fluazifop
2014	Fall	Mow
2015	Spring	Experimental Fluazifop
2016	Spring	Broadcast Fluazifop two times

Monitoring

We initiated botanical surveys at West Shore in May 2010. Two axes were superimposed on an aerial photo of the meadow (Figure 16) and coordinates were randomly selected for plot placement. We placed 1m aluminum conduit posts at 0, 100, and 200m along the longest axis, which extends North-South. We also placed conduit at 0 and 91m along the east-west short axis. Plots that were outside of the meadow were eliminated and replaced with another randomly selected location until 30 plots were selected. We placed a 1x1m sampling frame at the top right corner at each selected sampling point and estimated the percent cover of each species and ground cover category (bare ground, rock, and moss). Quantitative surveys were conducted again from 2011- 2013. Qualitative monitoring occurred in 2014 and 2015.

Results and Discussion

The native forb cover at this site has been steadily increasing since 2010 (Figure 17). However, treatments have been unsuccessful in reducing the non-native forbs at this site, specifically the non-native *Hypochaeris radicata*, dominant at this site with 23.2% cover in 2013. Since treating the area with grass-specific Fluazifop in 2011, the cover of

invasive grasses initially fell by nearly a half in 2012. By 2013, however, the cover of non-native grasses had rebounded to over 35%. The native graminoids cover in 2013 spiked to a high of 12%, most likely due to broadcast with Fluazifop in the spring of 2013.

In 2013, West Shore was dominated by *Hypochaeris radicata* (23.2% cover), *Anthoxanthum odoratum* (21.67% cover), *Arrhenatherum elatius* (14.1% cover), *Festuca roemerii* (8.5% cover), *Fragaria virginiana* (7.4% cover), and *Apocynum androsaemifolium* (5.1% cover) (Table 9, Appendix G). *Lupinus oreganus* was also present at the site, though not picked up in our survey in 2013. Several Fender's blue butterflies were observed at the site in 2010 and in 2013.

West Shore was qualitatively monitored in 2014 and 2015, and followed similar trends as in 2013. The site was dominated by introduced grasses *A. odoratum*, *A. elatius*, and a noted increase in cover of *Festuca arundinacea* (from 3% in 2013 to roughly 20% in 2015), which was extremely dense on the north end and the southwest portion of the site. *Festuca roemerii* has established well at this site with areas drill seeded still visible, covering roughly 8%. Also abundant were introduced forbs including *H. radicata* (25%), *P. lanceolata* (8%), and *D. carota* (5%). *Hypochaeris radicata* was particularly dense in small patches throughout the site. The native forb *F. virginiana* remained abundant at the site, composing roughly 15% in patchy abundance. *Rubus armeniacus* was patchy but common in the western portion of the site and along the edges (5%), suggesting need for ongoing treatment. The large patch of *Lupinus oreganus* was surrounded by lots of *Pteridium aquilinum* and high grass cover. This site had lots of bare ground and rodent activity in patches.

Management Recommendations

As invasive forbs are a particular problem at this site, we recommend spot-spraying with a broadleaf herbicide (e.g. 2,4-D). Continued maintenance of invasive grasses will be critical at this site. We also recommend spot treatments of *Rubus* and ongoing maintenance by mowing.

Table 9. Number of introduced and native species by growth habit found in 30 plots in 2013 at West Shore.

	Introduced	Native
Forb/herb	12	8
Graminoid	6	4
Tree, Shrub	2	3



Figure 16. West Shore upland prairie restoration site at Fern Ridge Lake. Aluminum conduit was placed at 0 and 91 m on the east/west axis and 0, 100, and 200 m on the north/south axis.

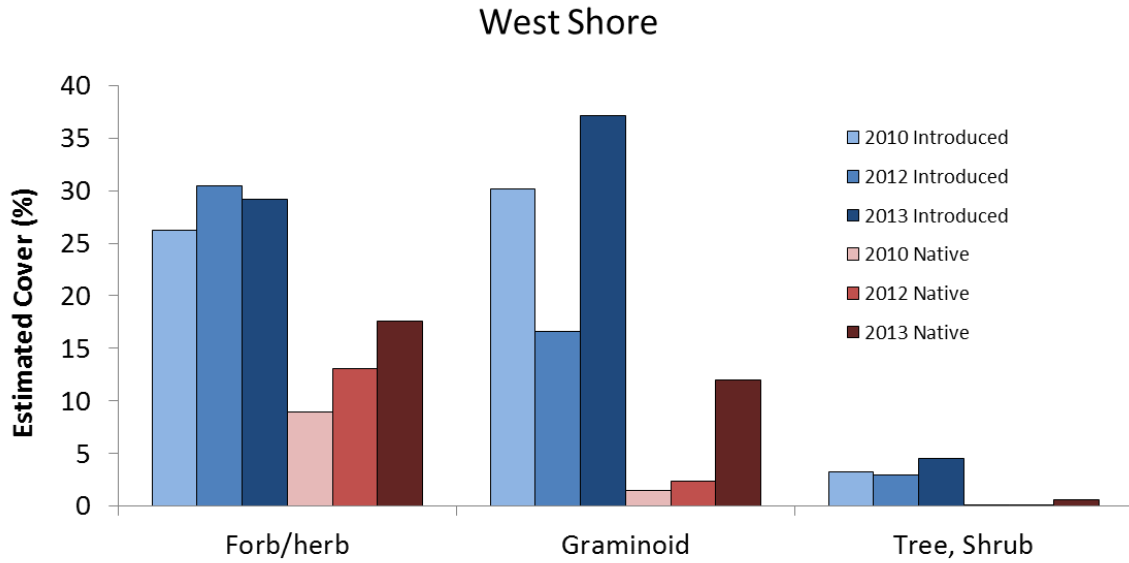


Figure 17. Cover estimates of introduced and native species in at West Shore for 2010 – 2013 (quantitative surveys were not conducted in 2011). Bars represent the sum of the average cover of species in each growth form. Estimated cover of each functional group*nativity = sum(average cover plot⁻¹ for each species in that category).

EAST SHORE

Although dominated by invasive grasses, East Shore has a relatively high cover of native forbs, including *Sidalcea*, *Fragaria*, and *L. oreganus*. Prior to 2011, management at this site included spring and fall mowing (Table 10).

Table 10. Treatment schedule for East Shore at Fern Ridge Lake. 2011 was the first year of restoration treatments at this site. Prior to 2011, the site was managed by spring and fall mowing.

Year	Season	Treatments
2011	Spring	Broadcast Fluazifop
2011	Fall	Assess
2012	Spring	None
2012	Fall	Fall mow
2013	Spring	Broadcast Fluazifop except east patch; hand weeding
2013	Fall	None
2014	Spring	Broadcast Fluazifop if needed
2014	Fall	Mow
2015		None
2016	Spring	Broadcast Fluazifop two times

Monitoring

We initiated botanical surveys at East Shore in May 2010. Two axes were superimposed on an aerial photo of the meadow (Figure 18) and coordinates were randomly selected for plot placement. We placed 1m aluminum conduit posts at 0, 100, and 158m along the longest axis, which extends East-West. Plots that were outside of the meadow were eliminated and replaced with another randomly selected location until 30 plots were selected. We placed a 1x1m sampling frame at the top right corner at each selected sampling point and estimated the percent cover of each species and ground cover category (bare ground, rock, and moss). Quantitative surveys were conducted again in 2012 and 2013. Qualitative monitoring occurred in 2014 and 2015.

Results and Discussion

In 2013, the most common species at East Shore were *Hypochaeris radicata* (35.8%), *Fragaria virginiana* (20.3%), *Arrhenatherum elatius* (12.5%), *Anthoxanthum odoratum* (introduced 12.3%), *Festuca arundinacea* (10.2%), *Plantago lanceolata* (5.1%), and *Vicia hirsuta* (4.9%) (Appendix H). From 2010 to 2013, overall cover of forbs increased with the introduced dramatically increasing in 2013 (Figure 19). After a drop in invasive graminoids in 2012, cover of the invasive graminoids increased again to greater than starting levels in 2010. Native graminoids have remained relatively stable at about 3%. *Lupinus oreganus* was present at the site, but was not picked up in sampling. The increase

in invasive graminoids is surprising given that the area was sprayed with grass-specific herbicide in the spring on 2013. The timing of this spraying and the weather conditions should be considered to maximize effectiveness of this treatment.

In qualitative monitoring conducted in 2014 and 2015, we noticed some changes since 2013. Introduced graminoids were still dominant across the site, however species composition tended to shift with a decline in introduced forbs and an increase in native forbs. *Hypochaeris radicata* declined from 35.9% to roughly 20% cover in 2014 and 10% cover in 2015. The site has some high quality patches of nectar species with high abundance of forbs including the natives *Fragaria virginiana* (20% in 2015) and *Sidalcea* sp. (15% in 2015); *Sidalcea* was barely present in 2013 (or was not picked up in our surveys). Introduced grasses continue to be the biggest threat at this site including *A. elatius* (10% in 2015). *Cytisus scoparius* was present in the northwest corner. *A. odoratum* tended to increase between 2014 and 2015, now covering roughly 20%, whereas *F. arundinacea* increased from roughly 10% in 2014 to 20% in 2015.

Management Recommendations

We recommend treatment of introduced graminoids and broadcast of fluazifop, followed by seeding of native species. We also recommend spot treatments of *Rubus* and ongoing maintenance by mowing. Shrubs such as *Crataegus* and *C. scoparius* should be monitored and spot-sprayed. Given the changes observed in 2014 and 2015, we recommend continued monitoring in 2016 to capture changes in plant community composition.



Figure 18. East Shore upland prairie restoration site at Fern Ridge Lake. Aluminum conduit was placed at 0, 100, and 158m on the east/west axis.

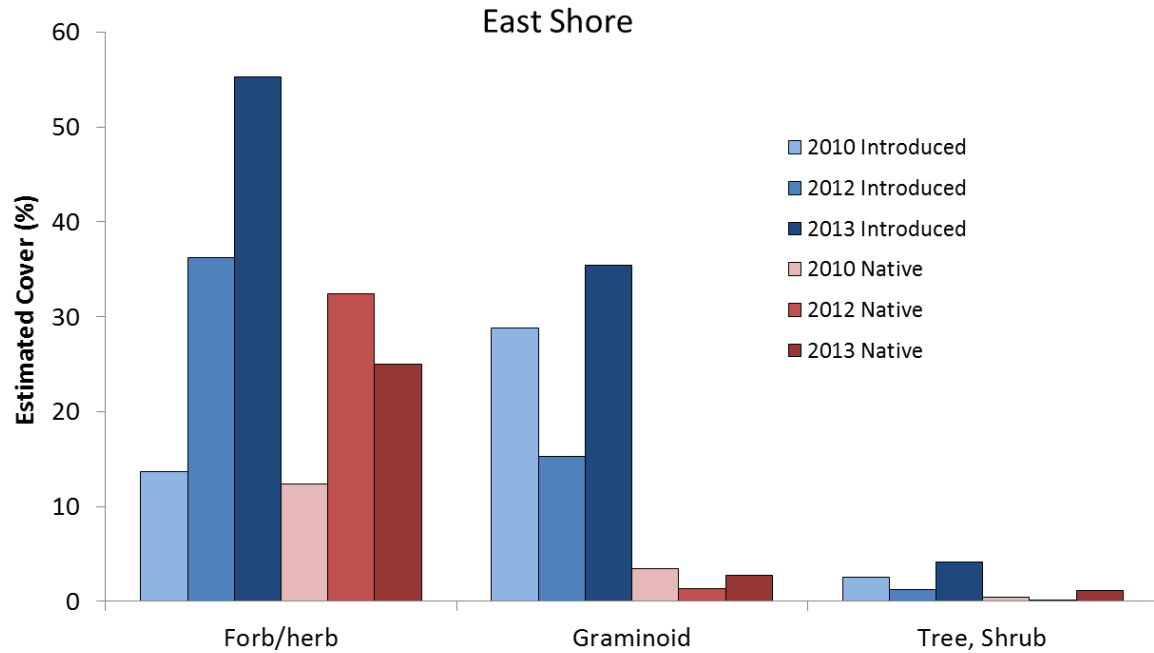


Figure 19. Cover estimates of introduced and native species in at East Shore for 2010, 2012, and 2013. Bars represent the sum of the average cover of species in each growth form. Estimated cover of each functional group*nativity = sum(average cover plot-1 for each species in that category).

WEST SPIRES

Although dominated by invasive grasses, West Spires has a relatively high cover of native forbs, including *Sidalcea*, *Pteridium*, *Fragaria* and some nice patches of *Lupinus oreganus*. Prior to 2011, management at this site included spring and fall mowing (Table 11).

Table 11. Treatment schedule for West Spires at Fern Ridge Lake. 2011 was the first year of restoration treatments at this site. Prior to 2011, the site was managed by spring and fall mowing.

Year	Season	Treatments
2010	Fall	Plant diversity in oak opening
2011	Spring	Broadcast Fluazifop on half
2011	Fall	Assess
2012	Spring	None
2012	Fall	Fall mow
2013	Spring	Broadcast Fluazifop on east half
2013	Fall	None
2014	Spring	Experimental or broadcast Fluazifop
2014	Fall	Fall mow, aminopyralid <i>Cytisus</i>
2015	Spring	Experimental Fluazifop
2016	Spring	Broadcast Fluazifop two times on the west half of the site

Monitoring

We initiated botanical surveys at West Spires in May 2010. Two axes were superimposed on an aerial photo of the meadow (Figure 21) and coordinates were randomly selected for plot placement. We placed 1m aluminum conduit posts at 0, 100, and 140m along the longest axis, which extends East-West. Plots that were outside of the meadow were eliminated and replaced with another randomly selected location until 30 plots were selected. We placed a 1x1m sampling frame at the top right corner at each selected sampling point and estimated the percent cover of each species and ground cover category (bare ground, rock, and moss). Quantitative surveys were conducted again in 2012 and 2013. The site was qualitatively monitored in 2014 and 2015.

Results and Discussion

As with the other upland prairie sites at Fern Ridge, West Spires was dominated by invasive graminoids in 2010, 2012, and 2013 (Figure 20). From 2010 to 2013, there was a dramatic increase in non-native forbs and graminoids (Figure 20). The most common species were the invasive grasses, *Arrhenatherum elatius* (27.3%), *Anthoxanthum odoratum* (23.9%), and *Festuca arundinacea* (13.3%); invasive forbs *Hypochaeris radicata* (13.3%) and *Plantago lanceolata* (2.9%); native grasses *Danthonia californica* (3%) and *Festuca roemerii* (2%); native forbs *Pteridium aquilinum* (6.1%) and *Fragaria virginiana* (5.9%);

introduced shrub *Rubus armeniacus* (2.5%) and *Cytisus scoparius* (1.8%); and native shrub *Rosa* (2.8%) (Appendix I). Although present in relatively low abundance, the invasive *Leucanthemum vulgare* was observed in the site. *Iris tenax*, a native nectar plant for Fender's blue butterfly was also present, though not captured in our monitoring plots. We found one patch of *Centaurea pratensis* near the path in the northeast part of the site (Figure 21). The increase in non-native graminoids is surprising given that the site was treated with grass-specific herbicide (Fluazifop) in the spring of 2013. The timing of this spraying and the weather conditions at the time of spraying should be considered to maximize effectiveness of this treatment.

Qualitative monitoring in 2014 and 2015 indicated that the introduced grasses have continued to dominate the site. We observed the same species dominating the site in recent years including introduced grasses *A. odoratum* (25%), *A. elatius* (30%), *F. arundinacea* (15%), and the introduced forb *H. radicata* (15%). We did see slight increases in native forbs, including *Sidalcea* sp. (6%) and *Fragaria virginiana* (10%) from 2013. Also present on the site are some nice patches of *L. oreganus* (4%). *Cytisus scoparius* increased slightly from 2013 and 2014 and *C. pratensis* was present in trace amounts. The site supported important forbs including *Iris tenax*, and *Sidalcea* sp. We noted areas of high cover of introduced grasses and *C. scoparius* in close proximity to *L. oreganus*.

Management Recommendations

Due to the high cover of introduced grasses, we recommend a grass specific herbicide followed by seeding with native grasses and continued planting of native forbs. We also recommend spot treatments of *Centaurea pratensis* and *Cytisus scoparius* and ongoing maintenance by mowing.

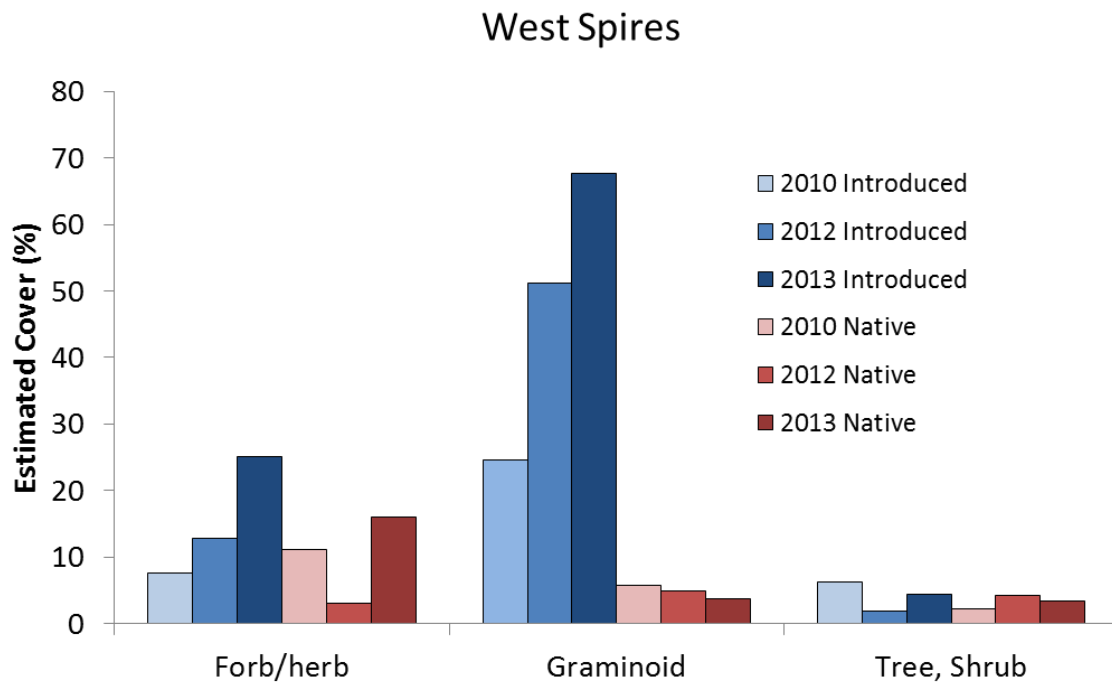


Figure 20. Cover estimates of introduced and native species in at West Spires from 2010 to 2013. Bars represent the sum of the average cover of species in each growth form. Estimated cover of each functional group*nativity = sum(average cover plot⁻¹ for each species in that category).



Figure 21. West Spires upland prairie restoration site at Fern Ridge Lake.

Centaurea pratensis was found in one patches within the site. 3' aluminum conduit was placed at 0 (East end), 100, and 140m on an axis running north-south. X and y-axes were superimposed on the meadow in order to randomly selected locations for samplina plots.

EAST SPIRES

Treatments at this site began in 2011. Qualitative monitoring took place in 2010, but quantitative data was only collected in 2012 and 2013. Qualitative monitoring was repeated in 2014 and 2015. Prior to 2011, management at this site included spring and fall mowing (Table 12).

Table 12. Treatment schedule for East Spires at Fern Ridge Lake. 2011 was the first year of restoration treatments at this site. Prior to 2011, the site was managed by spring and fall mowing.

Year	Season	Treatments
2011	Spring	Selectively treat forb weeds
2011	Fall	Burn, broadcast glyphosate, drill fescue, plant diversity
2012	Spring	Asses for broadcast, plant plugs
2012	Fall	Fall mow
2013	Spring	Cleared blackberry
2013	Fall	None
2014	Spring	Consider Fluazifop or aminopyralid patch treatments
2014	Fall	Mow

Monitoring

We initiated quantitative botanical surveys at East Spires in 2012. Two axes were superimposed on an aerial photo of the meadow (Figure 22) and coordinates were randomly selected for plot placement. We placed 1m aluminum conduit posts at 0, 100, and 129m along the longest axis, which extends north-south. Plots that were outside of the meadow were eliminated and replaced with another randomly selected location until 30 plots were selected. We placed a 1x1m sampling frame at the top right corner at each selected sampling point and estimated the percent cover of each species and ground cover category (bare ground, rock, and moss). Quantitative surveys were conducted in 2012 and 2013. The site was qualitatively monitored in 2014 and 2015.

Results and Discussion

As with the other upland prairie sites at Fern Ridge, East Spires was dominated by introduced graminoids (Figure 23). From 2012 to 2013, there was a dramatic increase in introduced graminoids (Figure 23). In 2013, the most common species were the introduced grasses, *Agrostis stolonifera* (40.2%), *Anthoxanthum odoratum* (31.2%), and *Festuca arundinacea* (12.5%); invasive forb *Hypochaeris radicata* (13.45%) and *Plantago lanceolata* (5.9%); native grass *Elymus glaucus* (5.2%); native forbs *Pteridium aquilinum* (4.1%) and *Lupinus oreganus* (2.3%); introduced shrub *Rubus armeniacus* (3%) and *Cytisus scoparius* (1.8%); and native shrub *Rosa* (1.2%) (Appendix J).

In qualitative monitoring in 2014 and 2015, the site remained dominated by introduced grasses with very low cover of native forbs. Dominant species included *A. odoratum* (35%), *A. stolonifera* (20%), *A. elatius* (15%), *F. arundinacea* (10%), and the forb *H. radicata* (10%). Other common species included *P. lanceolata* (8%) and *Vicia sativa* (5%). *Lupinus oreganus* was at the site

Management Recommendations

We recommend two years of treatment with a grass-specific herbicide, such as Fluazifop to reduce the cover of *Anthoxanthum* and *Agrostis* and seeding with native grasses and planting of native forbs. We also recommend treatments for non-native forbs including *H. radicata* and *P. maritima* and ongoing maintenance by mowing.



Figure 22. East Spires upland prairie restoration site at Fern Ridge Lake. 3' aluminum conduit was placed at 0 (West end), 100, and 129m on an axis running north-south. X and y-axes were superimposed on the meadow in order to randomly selected locations for sampling plots.

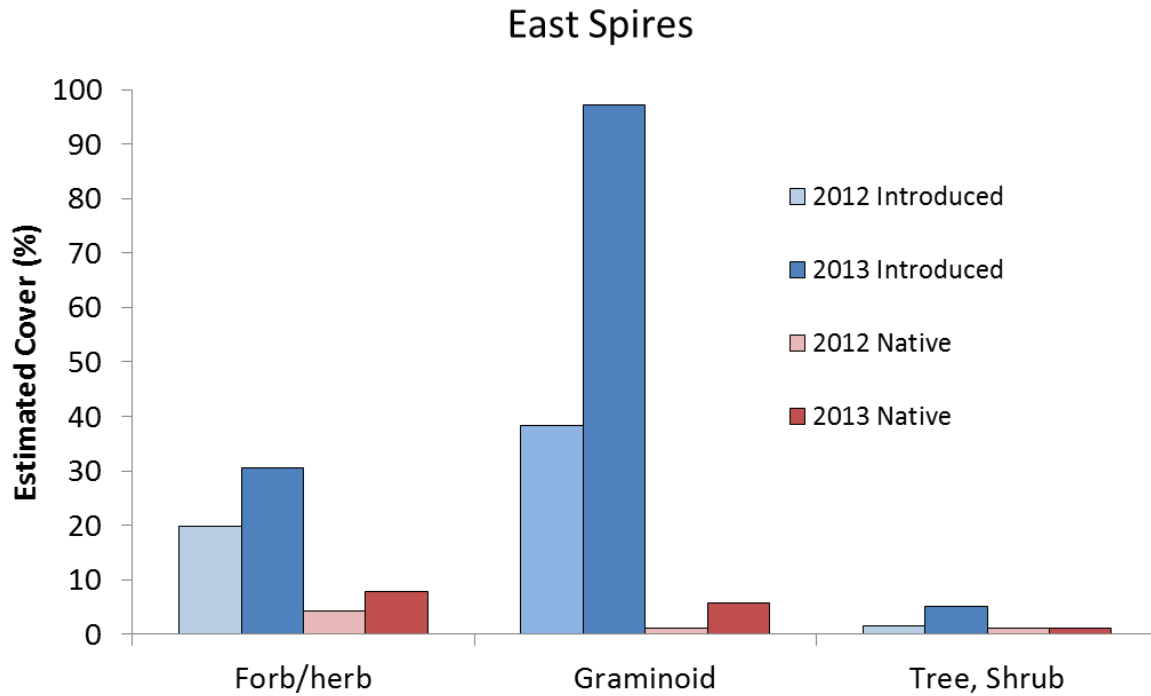


Figure 23. Cover estimates of introduced and native species in at East Spires from 2012 and 2013. Bars represent the sum of the average cover of species in each growth form. Estimated cover of each functional group*nativity = sum(average cover plot⁻¹ for each species in that category).

SUMMARY OF RECOMMENDED FUTURE ACTIONS

Monitoring: We recommend systematic monitoring (either quantitative or qualitative) of the sites each year, in with qualitative monitoring in early May and quantitative monitoring occurring in July.

Seeding: We recommend tailoring seed mixes to allow continued use of herbicides while components of the native plant community become established. For example, if introduced graminoids are persistent in the seed bank, seeding only native forbs in the first year would allow continued use of grass specific herbicides. Conversely, in sites where invasive forbs are the primary issues, native grasses could be seeded and aminopyralid applied for subsequent years.

Table 13. Monitoring schedule at upland prairie restoration sites at Fernridge Reservoir. “—” indicates no monitoring activities took place in that year. “Qual” indicates qualitative monitoring and “Quant” indicates quantitative monitoring.

	Acres	2008	2009	2010	2011	2012	2013	2014	2015	2016
Cherry Orchard	6.8	—	Quant	Qual	Qual	Qual	Qual	Quant	Quant	Quant
West Shore	4	—	—	Quant	Quant	Quant	Quant	Qual	Qual	Quant
East Shore	1.5	—	—	Quant	Quant	Quant	Quant	Qual	Qual	Quant
Big Spires	20	Quant	Quant	Qual (spring) Quant (fall)	Qual	Quant	Quant	Quant	Quant	Quant
West Spires	2.4	—	—	Quant	Qual	Quant	Quant	Qual	Qual	Quant
S of East Spires	1.3	—	Quant	Qual	Qual	—	—	Qual	Qual	—
East Spires	3	—	—	Qual	—	Quant	Quant	Qual	Qual	Quant
South Eaton c	3.3	—	Quant (as one site)	Qual	Qual	Qual	Qual	Qual	Quant	Quant
South Eaton E	2.4	—								
South Eaton W	3	—								
North Eaton	5	—	—	Quant, <i>Centaurea pratensis</i> surveys	Qual	Qual	Quant	Qual	Qual	Quant
South Green Oaks	2	—	—	Quant, <i>Centaurea pratensis</i> surveys	Qual	—	Qual	Qual	Quant	Qual

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APPENDIX A. AVERAGE COVER OF ALL SPECIES OBSERVED IN MONITORING PLOTS AT BIG SPIRES IN 2008 - 2015

Scientific Name	Nativity	Habit	Average cover						
			2008	2009	2010	2012	2013	2014	2015
<i>Achillea millefolium</i>	Native	Forb/herb	0.0	0.0	0.0	0.0	0.0	0.1	0.0
<i>Agrostis stolonifera</i>	Introduced	Graminoid	3.5	4.0	35.7	8.0	32.5	27.2	8.4
<i>Aira caryophylla</i>	Introduced	Graminoid	1.4	0.1	0.0	0.0	0.5	8.5	0.5
<i>Anthoxanthum odoratum</i>	Introduced	Graminoid	1.0	2.0	1.9	2.0	0.0	0.7	0.1
<i>Arrhenatherum elatius</i>	Introduced	Graminoid	29.7	24.6	0.0	0.6	5.3	3.1	0.2
<i>Aster hallii</i>	Native	Forb/herb	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<i>Briza minor</i>	Introduced	Graminoid	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<i>Bromus carinatus</i>	Native	Graminoid	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<i>Bromus hordeaceus</i>	Introduced	Graminoid	0.0	0.0	0.0	0.1	0.0	0.0	0.0
<i>Cardamine occidentalis</i>	Native	Forb/herb	0.0	0.1	0.0	0.0	0.0	0.0	0.0
<i>Centaurium erythraea</i>	Introduced	Forb/herb	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<i>Cerastium glomeratum</i>	Introduced	Forb/herb	0.0	0.5	0.2	0.1	0.0	0.2	0.0
<i>Cirsium</i>	Introduced	Forb/herb	0.0	0.0	0.2	0.0	0.0	0.0	0.1
<i>Clarkia amoena</i>	Native	Forb/herb	0.0	0.0	0.0	0.0	0.0	1.1	0.0
<i>Crepis capillaris</i>	Introduced	Forb/herb	0.3	0.7	0.0	0.1	0.1	0.2	0.0
<i>Crepis setosa</i>	Introduced	Forb/herb	0.0	0.5	0.0	0.0	0.0	0.0	0.0
<i>Dactylis glomerata</i>	Introduced	Graminoid	0.0	0.0	0.7	0.0	0.0	0.0	0.0
<i>Danthonia californica</i>	Native	Graminoid	0.0	0.0	0.0	0.1	0.2	0.2	0.0
<i>Daucus carota</i>	Introduced	Forb/herb	5.8	2.4	1.1	0.4	1.1	2.4	0.7
<i>Draba verna</i>	Introduced	Forb/herb	0.0	0.2	0.0	0.0	0.6	0.0	0.0
<i>Elymus glaucus</i>	Native	Graminoid	0.0	0.0	0.0	0.1	2.3	1.3	0.3
<i>Epilobium</i>	Native	Forb/herb	0.0	0.0	0.0	0.1	0.2	0.0	0.0
<i>Eriophyllum lanatum</i>	Native	Forb/herb	0.0	0.0	0.0	0.0	3.2	11.3	14.4
<i>Festuca arundinacea</i>	Introduced	Graminoid	0.0	0.0	7.1	0.9	0.0	0.0	0.0
<i>Festuca roemerii</i>	Native	Graminoid	0.0	0.2	8.4	18.7	53.7	25.6	57.7
<i>Fragaria virginiana</i>	Native	Forb/herb	0.2	0.3	0.0	0.2	0.0	0.0	0.0
<i>Galium parisiense</i>	Introduced	Forb/herb	11.5	1.7	0.2	0.1	0.5	2.7	0.0
<i>Galium sp.</i>	Introduced	Forb/herb	0.0	0.0	0.0	0.0	0.0	8.9	0.0
<i>Geranium dissectum</i>	Introduced	Forb/herb	0.0	0.0	0.0	0.1	0.0	0.0	0.0
<i>Gilia capitata</i>	Native	Forb/herb	0.0	0.0	0.0	0.1	0.1	0.0	0.0

<i>Gnaphalium sp.</i>	Introduced	Forb/herb	0.0	0.0	0.0	0.0	0.0	0.04	0.0
<i>Holcus lanatus</i>	Introduced	Graminoid	0.1	0.3	1.0	0.1	0.0	0.2	0.0
<i>Hypericum perforatum</i>	Introduced	Forb/herb	0.0	0.2	0.2	0.1	0.0	0.1	0.1
<i>Hypochaeris radicata</i>	Introduced	Forb/herb	3.4	1.5	0.3	0.0	2.2	2.1	4.5
<i>Koeleria macrantha</i>	Native	Graminoid	0.0	0.0	0.0	0.0	0.0	0.0	0.1
<i>Lactuca serriola</i>	Introduced	Forb/herb	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<i>Leucanthemum vulgare</i>	Introduced	Forb/herb	0.1	1.2	2.0	0.0	0.5	0.2	0.8
<i>Lotus micranthus</i>	Native	Forb/herb	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<i>Lotus unifoliolatus</i>	Native	Forb/herb	0.0	0.1	0.7	0.0	0.0	0.0	0.0
<i>Lupinus sp.</i>	Native	Forb/herb	0.0	0.0	0.0	0.0	0.0	0.3	0.0
<i>Microsteris gracilis</i>	Native	Forb/herb	0.1	0.0	0.0	0.0	0.0	0.0	0.0
<i>Myosotis discolor</i>	Introduced	Forb/herb	0.0	4.9	0.0	0.2	0.0	0.0	0.0
<i>Parentucellia viscosa</i>	Introduced	Forb/herb	3.2	1.1	0.0	0.4	0.2	7.5	0.6
<i>Plantago lanceolata</i>	Introduced	Forb/herb	0.6	0.0	0.0	0.1	2.7	3.6	6.9
<i>Potentilla gracillis</i>	Native	Forb/herb	0.0	0.0	0.0	0.1	0.4	0.3	0.2
<i>Prunella vulgaris</i>	Native	Forb/herb	0.0	0.0	0.4	0.2	1.4	0.9	0.6
<i>Prunus sp.</i>	Introduced	Tree, Shrub	0.0	0.0	0.0	0.0	0.2	0.0	0.0
<i>Pteridium aquilinum</i>	Native	Forb/herb	0.0	0.0	0.0	0.0	0.2	0.0	0.0
<i>Rosa sp.</i>	Native	Tree, Shrub	0.0	0.0	0.0	0.0	0.1	0.0	0.0
<i>Rubus armeniacus</i>	Introduced	Tree, Shrub	2.5	3.7	0.5	0.0	2.4	1.2	0.6
<i>Rumex acetosella</i>	Introduced	Forb/herb	1.1	1.1	0.6	3.5	0.9	3.7	1.3
<i>Senecio jacobaea</i>	Introduced	Forb/herb	0.0	0.0	0.0	0.0	0.3	0.0	0.0
<i>Sherardia arvensis</i>	Introduced	Forb/herb	0.0	0.0	0.0	0.0	0.0	0.0	2.2
<i>Sidalcea virgata</i>	Native	Forb/herb	0.0	0.0	0.1	0.2	0.0	0.2	0.2
<i>Sisyrinchium sp.</i>	Native	Forb/herb	0.0	0.0	0.0	0.1	0.0	0.0	0.0
<i>Spergula arvensis</i>	Introduced	Forb/herb	0.0	0.1	0.0	0.0	0.0	0.0	0.0
<i>Taraxacum officinale</i>	Introduced	Forb/herb	0.1	0.0	0.0	0.0	0.0	0.0	0.0
<i>unknown forb</i>	Introduced	Forb/herb	0.0	0.0	0.4	0.0	0.0	0.0	0.0
<i>Vicia hirsuta</i>	Introduced	Forb/herb	1.6	9.1	0.0	0.0	0.1	0.2	0.0
<i>Vicia sativa</i>	Introduced	Forb/herb	15.7	13.4	0.0	0.0	0.3	1.0	0.3
<i>Vulpia bromoides</i>	Introduced	Graminoid	1.5	1.4	0.0	5.3	7.9	9.4	9.1

APPENDIX B. AVERAGE COVER OF ALL SPECIES OBSERVED IN MONITORING PLOTS AT BIG SPIRES NE /WEST SPIRES IN 2009 AND 2013

Species	Nativity	Habit	2009	2013
<i>Acer macrophyllum</i>	Native	Tree, Shrub	0	0.07
<i>Achillea millefolium</i>	Native	Forb/herb	0	0.00
<i>Agrostis spp.</i>	Introduced	Graminoid	32.85	2.23
<i>Aira caryophylla</i>	Introduced	Graminoid	0	0.02
<i>Amelanchier alnifolia</i>	Native	Tree, Shrub	0	0.10
<i>Anthoxanthum odoratum</i>	Introduced	Graminoid	16.5	23.91
<i>Arrhenatherum elatius</i>	Introduced	Graminoid	0	27.33
<i>Brodiaea coronaria</i>	Native	Forb/herb	0	0.00
<i>Bromus hordeaceus</i>	Introduced	Graminoid	0.1	0.00
<i>Camassia quamash</i>	Native	Forb/herb	0	0.02
<i>Carex sp.</i>	Native	Graminoid	0	0.04
<i>Corylus sp.</i>	Native	Tree, Shrub	0	0.07
<i>Crataegus douglasii</i>	Native	Tree, Shrub	0.4	0.28
<i>Crepis capillaris</i>	Introduced	Forb/herb	1.4	0.11
<i>Crepis setosa</i>	Introduced	Forb/herb	0.9	0.10
<i>Cytisus scoparius</i>	Introduced	Shrub	0.7	1.80
<i>Dactylis glomerata</i>	Introduced	Graminoid	5.45	0.33
<i>Danthonia californica</i>	Native	Graminoid	0	0.35
<i>Daucus carota</i>	Introduced	Forb/herb	4.75	3.07
<i>Elymus glaucus</i>	Native	Graminoid	10.1	0.00
<i>Festuca arundinacea</i>	Introduced	Graminoid	9.9	13.33
<i>Festuca spp.</i>	Introduced	Graminoid	0.6	3.27
<i>Fragaria virginiana</i>	Native	Forb/herb	0	5.92
<i>Frangula</i>	Native	Tree, Shrub	0	0.10

<i>Galium aparine</i>	Native	Vine, Forb/herb	3.8	1.86
<i>Hedera spp.</i>	Introduced	Vine, Forb/herb	0.1	0.00
<i>Holcus lanatus</i>	Introduced	Graminoid	1.7	0.49
<i>Hypericum perforatum</i>	Introduced	Forb/herb	0	0.20
<i>Hypochaeris radicata</i>	Introduced	Forb/herb	0.75	13.33
<i>Lathyrus sphaericus</i>	Introduced	Forb/herb	0	0.10
<i>Leucanthemum vulgare</i>	Introduced	Forb/herb	0.7	0.20
<i>Lupinus oreganus</i>	Native	Forb/herb	0	1.77
<i>Luzula campestris</i>	Native	Graminoid	0.1	0.09
<i>Myosotis discolor</i>	Introduced	Forb/herb	0.1	0.00
<i>Parentucellia viscosa</i>	Introduced	Forb/herb	0.5	0.39
<i>Plantago lanceolata</i>	Introduced	Forb/herb	0.1	2.90
<i>Prunella vulgaris</i>	Native	Forb/herb	0	0.12
<i>Prunus spp.</i>	Introduced	Tree	0.1	0.00
<i>Pteridium aquilinum</i>	Native	Forb/herb	0.35	6.13
<i>Rosa spp.</i>	Native	Shrub	0.35	2.83
<i>Rubus armeniacus</i>	Introduced	Subshrub	2.35	2.57
<i>Rumex acetosella</i>	Introduced	Forb/herb	0	0.02
<i>Senecio jacobaea</i>	Introduced	Forb/herb	0.35	0.03
<i>Sidalcea</i>	Native	Forb/herb	0	2.01
<i>Solidago canadensis</i>	Native	Forb/herb	0.3	0.00
<i>Spiraea douglasii</i>	Native	Shrub	9.5	0.07
<i>Taraxacum officinale</i>	Introduced	Forb/herb	0.2	0.03
<i>Vicia hirsuta</i>	Introduced	Vine, Forb/herb	0.55	0.66
<i>Vicia sativa</i>	Introduced	Vine, Forb/herb	3.85	1.99

APPENDIX C. TOTAL MEAN COVER OF ALL SPECIES OBSERVED IN MONITORING PLOTS AT CHERRY ORCHARD IN 2009, 2014 AND 2015

Species	Nativity	Habit	2009	2014	2015
<i>Agrostis stolonifera</i>	Introduced	Graminoid	3.6	31.3	20.0
<i>Aira caryophyllea</i>	Introduced	Graminoid	0.0	0.2	0.0
<i>Anthoxanthum odoratum</i>	Introduced	Graminoid	4.4	0.5	3.0
<i>Apocynum androsaemifolium</i>	Native	Forb/herb	0.0	3.3	1.2
<i>Arrhenatherum elatius</i>	Introduced	Graminoid	24.9	4.6	3.2
<i>Centaureum erythraea</i>	Introduced	Forb/herb	0.0	0.0	0.0
<i>Crataegus douglasii</i>	Native	Shrub	0.2	0.0	0.0
<i>Crepis capillaris</i>	Introduced	Forb/herb	1.2	0.0	0.0
<i>Crepis setosa</i>	Introduced	Forb/herb	1.2	0.0	0.5
<i>Cytisus scoparius</i>	Introduced	Shrub	0.5	0.0	0.0
<i>Dactylis glomerata</i>	Introduced	Graminoid	0.9	0.0	0.0
<i>Daucus carota</i>	Introduced	Forb/herb	3.6	0.0	0.4
<i>Festuca arundinacea</i>	Introduced	Graminoid	14.9	0.0	0.0
<i>Festuca roemerii</i>	Native	Graminoid	0.0	48.9	51.9
<i>Galium parisiense</i>	Introduced	Forb/herb	0.7	0.0	0.0
<i>Galium sp.</i>	Introduced	Forb/herb	0.0	3.0	0.0
<i>Geranium dissectum</i>	Introduced	Forb/herb	0.0	0.0	0.0
<i>Holcus lanatus</i>	Introduced	Graminoid	1.5	1.6	2.0
<i>Hypericum perforatum</i>	Introduced	Forb/herb	0.0	0.0	0.2
<i>Hypochaeris radicata</i>	Introduced	Forb/herb	4.0	0.9	0.4
<i>Leontodon taraxacoides</i>	Introduced	Forb/herb	0.7	0.0	0.0
<i>Luzula campestris</i>	Native	Graminoid	0.2	0.0	0.0
<i>Myosotis discolor</i>	Introduced	Forb/herb	0.2	0.0	0.0
<i>Parentucellia viscosa</i>	Introduced	Forb/herb	0.0	4.9	1.9
<i>Phalaris arundinacea</i>	Introduced	Graminoid	0.1	0.0	0.0
<i>Plantago lanceolata</i>	Introduced	Forb/herb	0.2	0.4	1.0
<i>Potentilla gracillis</i>	Native	Forb/herb	0.0	0.0	0.0

<i>Pteridium aquilinum</i>	Native	Forb/herb	0.2	0.0	0.2
<i>Ranunculus occidentalis</i>	Native	Forb/herb	0.0	0.0	0.0
<i>Rosa spp.</i>	Native	Shrub	0.1	0.0	0.0
<i>Rubus armeniacus</i>	Introduced	Shrub	1.2	0.1	0.0
<i>Rumex acetosella</i>	Introduced	Forb/herb	0.3	0.0	0.2
<i>Senecio jacobaea</i>	Introduced	Forb/herb	0.0	0.0	0.0
<i>Senecio vulgaris</i>	Introduced	Forb/herb	0.1	0.0	0.0
<i>Sherardia arvensis</i>	Introduced	Forb/herb	0.0	0.0	1.0
<i>Sidalcea campestris</i>	Native	Forb/herb	0.0	0.0	0.0
<i>Taraxacum officinale</i>	Introduced	Forb/herb	0.4	0.1	0.0
<i>Toxicodendron diversilobum</i>	Native	Forb/herb	0.0	0.0	0.0
<i>Vicia hirsuta</i>	Introduced	Forb/herb	1.3	0.0	0.0
<i>Vicia sativa</i>	Introduced	Forb/herb	4.7	0.1	0.2
<i>Vulpia bromoides</i>	Introduced	Graminoid	0.0	0.1	4.1

APPENDIX D. AVERAGE COVER OF ALL SPECIES OBSERVED IN MONITORING PLOTS AT SOUTH EATON IN 2009 AND 2014. NOTE IN 2009 TREATED AND UNTREATED PLOTS WERE MONITORED, WHEREAS IN 2015 THE SITE WAS BROEKN INTO THREE SECTIONS (WEST, CENTRAL, EAST).

Species	Nativity	Habit	2009		2015			
			Untreated	Treated	West	Central	East	All
<i>Agrostis</i> sp.	Introduced	Graminoid	22.2	7.5	35.2	14.6	28.9	26.2
<i>Aira caryophylllea</i>	Introduced	Graminoid	3.0	1.0	3.4	13.7	2.1	6.4
<i>Anthoxanthum odoratum</i>	Introduced	Graminoid	20.3	5.8	0.0	0.5	0.6	0.4
<i>Arrhenatherum elatius</i>	Introduced	Graminoid	8.9	2.9	0.0	1.7	0.0	0.6
<i>Aster hallii</i>	Native	Forb/herb	0.0	0.0	0.1	0.0	0.0	0.0
<i>Bromus carinatus</i>	Native	Graminoid	0.1	19.8	0.0	0.0	0.2	0.1
<i>Bromus hordeaceus</i>	Introduced	Graminoid	0.0	3.9	0.0	0.0	0.0	0.0
<i>Bromus rigidus</i>	Introduced	Graminoid	0.0	1.4	0.0	0.0	0.0	0.0
<i>Centaureum erythraea</i>	Introduced	Forb/herb	0.0	0.0	0.0	0.4	0.4	0.3
<i>Cerastium glomeratum</i>	Introduced	Forb/herb	0.1	0.1	0.0	0.0	0.0	0.0
<i>Crepis capillaris</i>	Introduced	Forb/herb	0.0	0.5	0.0	0.0	0.0	0.0
<i>Crepis setosa</i>	Introduced	Forb/herb	2.3	5.4	0.0	0.0	0.0	0.0
<i>Cytisus scoparius</i>	Introduced	Shrub	0.2	0.0	0.0	0.5	0.5	0.3
<i>Dactylis glomerata</i>	Introduced	Graminoid	0.7	0.0	0.0	0.0	0.0	0.0
<i>Daucus carota</i>	Introduced	Forb/herb	4.3	9.3	0.8	3.2	0.4	1.5
<i>Draba verna</i>	Introduced	Forb/herb	0.1	0.0	0.0	0.0	0.0	0.0
<i>Elymus glaucus</i>	Native	Graminoid	8.7	7.5	0.0	0.0	0.0	0.0
<i>Eriophyllum lanatum</i>	Native	Forb/herb	0.0	0.0	0.1	0.0	0.1	0.1
<i>Festuca arundinacea</i>	Introduced	Graminoid	2.1	1.1	0.0	0.0	0.0	0.0
<i>Festuca roemerii</i>	Native	Graminoid	0.0	0.0	53.6	6.9	44.8	35.1
<i>Fragaria virginiana</i>	Native	Forb/herb	1.2	0.4	0.0	0.0	0.0	0.0
<i>Galium</i> spp.	Introduced	Forb/herb	0.6	2.8	0.0	0.5	0.0	0.2
<i>Holcus lanatus</i>	Introduced	Graminoid	0.5	0.1	0.0	0.0	0.0	0.0
<i>Hypericum perforatum</i>	Introduced	Forb/herb	0.0	0.0	0.7	3.5	1.4	1.9
<i>Hypochaeris radicata</i>	Introduced	Forb/herb	15.8	26.9	8.5	26.1	20.3	18.3

<i>Leontodon taraxacoides</i>	Introduced	Forb/herb	0.1	0.2	0.0	0.0	0.0	0.0
<i>Lotus unifoliolatus</i>	Native	Forb/herb	0.0	0.1	0.0	0.0	0.0	0.0
<i>Luzula campestris</i>	Native	Graminoid	1.0	0.3	0.0	0.0	0.0	0.0
<i>Myosotis discolor</i>	Introduced	Forb/herb	0.3	0.8	0.0	0.0	0.0	0.0
<i>Narcissus pseudonarcissus</i>	Introduced	Forb/herb	0.5	0.0	0.0	0.0	0.0	0.0
<i>Parentucellia viscosa</i>	Introduced	Forb/herb	0.5	0.2	0.3	1.0	0.4	0.5
<i>Plantago lanceolata</i>	Introduced	Forb/herb	1.4	0.2	4.2	14.9	0.0	6.4
<i>Prunus</i> spp.	Native	Tree	0.1	0.0	0.0	0.0	0.0	0.0
<i>Pteridium aquilinum</i>	Native	Forb/herb	0.1	0.0	0.0	0.0	0.0	0.0
<i>Quercus garryana</i>	Native	Tree, Shrub	0.0	0.0	0.0	0.0	0.1	0.0
<i>Rosa</i> spp.	Native	Shrub	0.6	0.0	0.0	0.0	0.0	0.0
<i>Rubus armeniacus</i>	Introduced	Shrub	1.9	1.5	0.0	0.0	0.0	0.0
<i>Rumex acetosella</i>	Introduced	Forb/herb	0.3	0.0	0.1	5.6	0.1	1.9
<i>Sidalcea</i> spp.	Native	Forb/herb	0.0	0.1	0.0	0.0	0.0	0.0
<i>Spiraea douglasii</i>	Native	Shrub	0.0	0.0	0.0	0.0	0.0	0.0
<i>Sherardia arvensis</i>	Introduced	Forb/herb	0.0	0.0	0.0	2.4	1.2	1.4
<i>Taraxacum officinale</i>	Introduced	Forb/herb	0.0	0.0	0.0	0.0	0.0	0.0
<i>Vicia hirsuta</i>	Introduced	Forb/herb	2.4	11.8	0.0	0.0	0.0	0.0
<i>Vicia sativa</i>	Introduced	Forb/herb	7.7	21.8	0.7	0.4	0.4	0.5
<i>Vulpia bromoides</i>	Introduced	Graminoid	2.0	3.8	2.2	7.8	4.0	4.7

APPENDIX E. AVERAGE COVER OF ALL SPECIES OBSERVED IN
MONITORING PLOTS AT NORTH EATON IN 2010 AND 2013

Species	Nativity	Habit	2010	2013
<i>Agrostis stolonifera</i>	Introduced	Graminoid	7.20	19.34
<i>Aira caryophyllea</i>	Introduced	Graminoid	0.10	0.38
<i>Amelanchier alnifolia</i>	Native	Tree, Shrub	0.00	0.06
<i>Alnus rubra</i>	Native	Tree, Shrub	0.00	0.00
<i>Anthoxanthum odoratum</i>	Introduced	Graminoid	29.90	21.63
<i>Arrhenatherum elatius</i>	Introduced	Graminoid	2.50	2.97
<i>Brodiaea</i>	Native	Forb/herb	0.10	0.13
<i>Bromus hordeaceus</i>	Introduced	Graminoid	0.30	0.00
<i>Centaureum erythraea</i>	Introduced	Forb/herb	0.00	0.18
<i>Cerastium glomeratum</i>	Introduced	Forb/herb	0.00	0.00
<i>Crataegus douglasii</i>	Native	Tree, Shrub	0.00	0.00
<i>Crepis capillaris</i>	Introduced	Forb/herb	0.10	0.00
<i>Crepis setosa</i>	Introduced	Forb/herb	0.00	0.00
<i>Cytisus scoparius</i>	Introduced	Tree, Shrub	1.30	0.46
<i>Dactylis glomerata</i>	Introduced	Graminoid	0.80	0.00
<i>Danthonia californica</i>	Native	Graminoid	0.70	0.00
<i>Daucus carota</i>	Introduced	Forb/herb	0.30	0.05
<i>Draba verna</i>	Introduced	Forb/herb	0.30	0.00
<i>Elymus glaucus</i>	Native	Graminoid	1.30	0.00
<i>Elytrigia repens</i>	Introduced	Graminoid	0.40	0.00
<i>Festuca arundinacea</i>	Introduced	Graminoid	2.30	0.00
<i>Festuca roemerii</i>	Native	Graminoid	2.50	41.83
<i>Galium aparine</i>	Native	Forb/herb	0.40	0.00
<i>Galium parisiense</i>	Introduced	Forb/herb	0.30	3.87

<i>Holcus lanatus</i>	Introduced	Graminoid	0.10	0.27
<i>Hypericum perforatum</i>	Introduced	Forb/herb	0.20	0.88
<i>Hypochaeris radicata</i>	Introduced	Forb/herb	7.80	1.34
<i>Iris tenax</i>	Native	Forb/herb	0.10	0.00
<i>Lotus unifoliolatus</i>	Native	Forb/herb	0.10	0.00
<i>Lupinus oreganus</i>	Native	Forb/herb	1.10	0.40
<i>Luzula</i>	Native	Graminoid	0.40	0.00
<i>Myosotis discolor</i>	Introduced	Forb/herb	0.30	0.00
<i>Parentucellia viscosa</i>	Introduced	Forb/herb	0.20	0.75
<i>Plantago lanceolata</i>	Introduced	Forb/herb	0.50	0.09
<i>Prunella vulgaris</i>	Native	Forb/herb	0.00	0.07
<i>Pseudotsuga menziesii</i>	Native	Tree, Shrub	0.00	0.01
<i>Pteridium aquilinum</i>	Native	Forb/herb	0.30	1.13
<i>Quercus garryana</i>	Native	Tree, Shrub	1.30	0.01
<i>Rosa</i>	Introduced	Tree, Shrub	0.10	0.01
<i>Rubus armeniacus</i>	Introduced	Tree, Shrub	0.50	1.43
<i>Rubus laciniatus</i>	Introduced	Tree, Shrub	0.00	0.00
<i>Rumex acetosella</i>	Introduced	Forb/herb	0.20	0.17
<i>Spiraea douglasii</i>	Native	Tree, Shrub	0.00	0.00
<i>Symphoricarpos albus</i>	Native	Tree, Shrub	0.00	0.00
<i>Vicia cracca</i>	Introduced	Forb/herb	0.30	0.00
<i>Vicia hirsuta</i>	Introduced	Forb/herb	0.30	0.00
<i>Vicia sativa</i>	Introduced	Forb/herb	0.40	0.02
<i>Vulpia bromoides</i>	Introduced	Graminoid	0.00	0.00

APPENDIX F. AVERAGE COVER OF ALL SPECIES OBSERVED IN MONITORING PLOTS AT SOUTH GREEN OAKS IN 2010 AND 2015

Species	US Nativity	Growth Habit	Average cover			
			2010 Mean	2010 SE	2015 Mean	2015 SE
<i>Agrostis stolonifera</i>	Introduced	Graminoid	10.8	2.3	11.2	2.5
<i>Aira caryophyllea</i>	Introduced	Graminoid	5.0	1.2	1.5	0.3
<i>Alnus rubra</i>	Native	Tree, Shrub	5.4	2.3	0.0	0.0
<i>Amelanchier alnifolia</i>	Native	Tree, Shrub	0.2	0.1	0.0	0.0
<i>Anthoxanthum odoratum</i>	Introduced	Graminoid	13.4	2.6	8.9	1.4
<i>Apocynum androsaemifolium</i>	Native	Forb/herb	0.0	0.0	0.8	0.3
<i>Arrhenatherum elatius</i>	Introduced	Graminoid	0.1	0.1	0.1	0.1
<i>Bromus carinatus</i>	Native	Graminoid	0.3	0.2	0.0	0.0
<i>Bromus hordeaceus</i>	Introduced	Graminoid	1.0	0.4	5.6	2.0
<i>Centaurea pratensis</i>	Introduced	Forb/herb	0.0	0.0	0.0	0.0
<i>Crataegus douglasii</i>	Native	Tree, Shrub	0.1	0.1	0.0	0.0
<i>Crepis capillaris</i>	Introduced	Forb/herb	0.8	0.6	0.0	0.0
<i>Crepis setosa</i>	Introduced	Forb/herb	0.0	0.0	0.0	0.0
<i>Cynosurus echinatus</i>	Introduced	Graminoid	0.0	0.0	0.0	0.0
<i>Danthonia californica</i>	Native	Graminoid	0.4	0.3	1.7	0.8
<i>Daucus carota</i>	Introduced	Forb/herb	1.3	0.2	18.5	2.7
<i>Draba verna</i>	Introduced	Forb/herb	0.2	0.1	0.0	0.0
<i>Eriophyllum lanatum</i>	Native	Forb/herb	0.1	0.0	0.0	0.0
<i>Festuca arundinacea</i>	Introduced	Graminoid	0.2	0.1	0.1	0.1
<i>Festuca roemerii</i>	Native	Graminoid	0.0	0.0	0.0	0.0
<i>Galium aparine</i>	Native	Forb/herb	0.3	0.2	0.0	0.0
<i>Galium parisiense</i>	Introduced	Forb/herb	0.5	0.2	0.0	0.0
<i>Hypericum perforatum</i>	Introduced	Forb/herb	0.1	0.0	0.0	0.0
<i>Hypochaeris radicata</i>	Introduced	Forb/herb	19.5	3.8	44.9	5.1
<i>Lupinus oreganus</i>	Native	Forb/herb	0.0	0.0	0.2	0.1
<i>Luzula</i>	Native	Graminoid	0.1	0.0	0.0	0.0

<i>Myosotis discolor</i>	Introduced	Forb/herb	0.1	0.0	0.0	0.0
<i>Plantago lanceolata</i>	Introduced	Forb/herb	0.3	0.1	0.4	0.2
<i>Rosa eglanteria</i>	Introduced	Tree, Shrub	0.1	0.1	0.0	0.0
<i>Rubus armeniacus</i>	Introduced	Tree, Shrub	0.6	0.3	0.3	0.2
<i>Rumex acetosella</i>	Introduced	Forb/herb	0.1	0.1	0.3	0.3
<i>Sherardia arvensis</i>	Introduced	Forb/herb	0.0	0.0	4.2	1.4
<i>Sidalcea virgata</i>	Native	Forb/herb	0.0	0.0	0.0	0.0
<i>Vicia cracca</i>	Introduced	Forb/herb	0.1	0.0	0.0	0.0
<i>Vicia hirsuta</i>	Introduced	Forb/herb	0.1	0.0	0.0	0.0
<i>Vicia sativa</i>	Introduced	Forb/herb	0.1	0.0	0.0	0.0
<i>Vulpia bromoides</i>	Introduced	Graminoid	3.3	0.9	0.1	0.1

APPENDIX G. COVER OF ALL SPECIES OBSERVED IN MONITORING PLOTS AT WEST SHORE IN 2010 AND 2013.

Species	US Nativity	Growth Habit	2010	2013
<i>Agrostis stolonifera</i>	Introduced	Graminoid	3.2	0.60
<i>Aira caryophyllea</i>	Introduced	Graminoid	0	0.27
<i>Alopecurus pratensis</i>	Introduced	Graminoid	0	0.33
<i>Amelanchier alnifolia</i>	Native	Tree, Shrub	0.1	0.13
<i>Anthoxanthum odoratum</i>	Introduced	Graminoid	12.4	21.67
<i>Apocynum androsaemifolium</i>	Native	Forb/herb	0.5	5.10
<i>Arrhenatherum elatius</i>	Introduced	Graminoid	3.4	14.13
<i>Cerastium glomeratum</i>	Introduced	Forb/herb	0	0
<i>Crataegus douglasii</i>	Native	Tree, Shrub	0.1	0.26
<i>Crepis capillaris</i>	Introduced	Forb/herb	1.2	0.033
<i>Crepis setosa</i>	Introduced	Forb/herb	3.8	0
<i>Cytisus scoparius</i>	Introduced	Tree, Shrub	0.2	0
<i>Dactylis glomerata</i>	Introduced	Graminoid	1.9	0
<i>Danthonia californica</i>	Native	Graminoid	0.1	0.2
<i>Daucus carota</i>	Introduced	Forb/herb	1.7	1.21
<i>Festuca arundinacea</i>	Introduced	Graminoid	9	2.93
<i>Festuca roemerii</i>	Native	Graminoid	1.3	8.5
<i>Fragaria virginiana</i>	Native	Forb/herb	6.1	7.43
<i>Galium aparine</i>	Native	Forb/herb	0.2	0.15
<i>Galium parisiense</i>	Introduced	Forb/herb	0.1	0.39
<i>Holcus lanatus</i>	Introduced	Graminoid	0.2	0.17
<i>Hypericum perforatum</i>	Introduced	Forb/herb	0.1	0.10
<i>Hypochaeris radicata</i>	Introduced	Forb/herb	15.4	23.2
<i>Ilex aquifolium</i>	Introduced	Tree, Shrub	0.1	0
<i>Ipomoea</i>	Introduced	Forb/herb	0.3	0

<i>Leucanthemum vulgare</i>	Introduced	Forb/herb	0.4	0.18
<i>Lotus unifoliolatus</i>	Native	Forb/herb	0	0
<i>Lupinus oreganus</i>	Native	Forb/herb	0.4	0.16
<i>Luzula</i>	Native	Graminoid	0.1	0.34
<i>Myosotis discolor</i>	Introduced	Forb/herb	0.2	0.003
<i>Parentucellia viscosa</i>	Introduced	Forb/herb	0.1	0.18
<i>Plantago lanceolata</i>	Introduced	Forb/herb	1.5	3.18
<i>Polystichum munitum</i>	Native	Forb/herb	0	0
<i>Prunella vulgaris</i>	Native	Forb/herb		0.1
<i>Prunus avium</i>	Introduced	Tree, Shrub	0	0
<i>Pteridium aquilinum</i>	Native	Forb/herb	0.8	3.43
<i>Rosa</i>	Introduced	Tree, Shrub	1.2	2
<i>Rubus armeniacus</i>	Introduced	Tree, Shrub	1.8	2.5
<i>Rumex acetosella</i>	Introduced	Forb/herb	0.1	0
<i>Senecio jacobaea</i>	Introduced	Forb/herb	0	0
<i>Senecio vulgaris</i>	Introduced	Forb/herb	0	0
<i>Sidalcea campestris</i>	Native	Forb/herb	0.8	1.11
<i>Taraxacum officinale</i>	Introduced	Forb/herb	0.8	0
<i>unknown forb</i>	Introduced	Forb/herb	0	0
<i>Vicia cracca</i>	Introduced	Forb/herb	0.1	0
<i>Vicia hirsuta</i>	Introduced	Forb/herb	0.3	0.63
<i>Vicia sativa</i>	Introduced	Forb/herb	0.2	0.01

APPENDIX H. COVER OF ALL SPECIES OBSERVED IN MONITORING PLOTS AT EAST SHORE IN 2010 AND 2013

Species	Nativity	Habit	Cover	
			2010	2013
<i>Agrostis stolonifera</i>	Introduced	Graminoid	0.4	0.0
<i>Aira caryophyllea</i>	Introduced	Forb/herb	0.0	0.0
<i>Amelanchier</i>	Native	Tree, Shrub	0.0	0.1
<i>Anthoxanthum odoratum</i>	Introduced	Graminoid	6.5	12.4
<i>Apocynum androsaemifolium</i>	Native	Forb/herb	0.2	3.6
<i>Arrhenatherum elatius</i>	Introduced	Graminoid	5.1	12.5
<i>Carex</i>	Native	Graminoid	0.0	0.5
<i>Cerastium glomeratum</i>	Introduced	Forb/herb	0.0	0.0
<i>Cirsium</i>	Introduced	Forb/herb	0.1	0.0
<i>Crataegus douglasii</i>	Native	Tree, Shrub	0.1	0.4
<i>Crepis capillaris</i>	Introduced	Forb/herb	0.2	0.2
<i>Crepis setosa</i>	Introduced	Forb/herb	1.8	0.8
<i>Cytisus scoparius</i>	Introduced	Tree, Shrub	0.1	0.0
<i>Dactylis glomerata</i>	Introduced	Graminoid	1.6	0.0
<i>Danthonia californica</i>	Native	Graminoid	3.0	0.2
<i>Daucus carota</i>	Introduced	Forb/herb	0.9	2.0
<i>Eriophyllum lanatum</i>	Native	Forb/herb	0.0	0.0

<i>Festuca arundinacea</i>	Introduced	Graminoid	15.1	10.2
<i>Festuca roemerii</i>	Native	Graminoid	0.1	0.4
<i>Fragaria virginiana</i>	Native	Forb/herb	7.4	20.4
<i>Frangula</i>	Native	Tree, Shrub	0.0	0.6
<i>Fraxinus latifolia</i>	Native	Tree, Shrub	0.0	0.1
<i>Galium aparine</i>	Native	Forb/herb	0.2	0.0
<i>Galium parisiense</i>	Introduced	Forb/herb	0.2	1.9
<i>Holcus lanatus</i>	Introduced	Graminoid	0.1	0.3
<i>Hypericum perforatum</i>	Introduced	Forb/herb	0.0	0.3
<i>Hypochaeris radicata</i>	Introduced	Forb/herb	9.1	35.9
<i>Leucanthemum vulgare</i>	Introduced	Forb/herb	0.2	2.2
<i>Lotus unifoliolatus</i>	Native	Forb/herb	0.0	0.0
<i>Lupinus oreganus</i>	Native	Forb/herb	1.0	0.0
<i>Luzula</i>	Native	Graminoid	0.3	1.7
<i>Marah oreganus</i>	Native	Forb/herb	0.0	0.0
<i>Myosotis discolor</i>	Introduced	Forb/herb	0.1	0.0
<i>Parentucellia viscosa</i>	Introduced	Forb/herb	0.0	0.1
<i>Plantago lanceolata</i>	Introduced	Forb/herb	0.2	5.1
<i>Poa pratensis</i>	Introduced	Graminoid	0.0	0.0
<i>Prunus emarginata</i>	Native	Tree, Shrub	0.3	0.0
<i>Pteridium aquilinum</i>	Native	Forb/herb	0.2	0.1

<i>Ranunculus occidentalis</i>	Native	Forb/herb	0.1	0.0
<i>Rosa</i>	Introduced	Tree, Shrub	1.1	0.2
<i>Rubus armeniacus</i>	Introduced	Tree, Shrub	1.3	4.0
<i>Rumex acetosella</i>	Introduced	Forb/herb	0.0	0.5
<i>Senecio jacobaea</i>	Introduced	Forb/herb	0.0	0.2
<i>Senecio vulgaris</i>	Introduced	Forb/herb	0.0	0.0
<i>Sidalcea</i>	Native	Forb/herb	3.2	0.9
<i>Symphoricarpos albus</i>	Native	Tree, Shrub	0.1	0.0
<i>Taraxacum officinale</i>	Introduced	Forb/herb	0.3	0.1
<i>Vicia cracca</i>	Introduced	Forb/herb	0.0	0.0
<i>Vicia hirsuta</i>	Introduced	Forb/herb	0.3	4.9
<i>Vicia sativa</i>	Introduced	Forb/herb	0.1	1.1
<i>Vulpia bromoides</i>	Introduced	Graminoid	0.0	0.0
<i>Zigadenus venenosus</i>	Native	Forb/herb	0.0	0.0

APPENDIX I. COVER OF ALL SPECIES OBSERVED IN MONITORING PLOTS AT WEST SPIRES IN 2009 AND 2013

Species	Nativity	Habit	2009	2013
<i>Acer macrophyllum</i>	Native	Tree, Shrub	0	0.07
<i>Achillea millefolium</i>	Native	Forb/herb	0	0.00
<i>Agrostis spp.</i>	Introduced	Graminoid	32.85	2.23
<i>Aira caryophylla</i>	Introduced	Graminoid	0	0.02
<i>Amelanchier alnifolia</i>	Native	Tree, Shrub	0	0.10
<i>Anthoxanthum odoratum</i>	Introduced	Graminoid	16.5	23.91
<i>Arrhenatherum elatius</i>	Introduced	Graminoid	0	27.33
<i>Brodiaea coronana</i>	Native	Forb/herb	0	0.00
<i>Bromus hordeaceus</i>	Introduced	Graminoid	0.1	0.00
<i>Camassia quamash</i>	Native	Forb/herb	0	0.02
<i>Carex</i>	Native	Graminoid	0	0.04
<i>Corylus sp.</i>	Native	Tree, Shrub	0	0.07
<i>Crataegus douglasii</i>	Native	Tree, Shrub	0.4	0.28
<i>Crepis capillaris</i>	Introduced	Forb/herb	1.4	0.11
<i>Crepis setosa</i>	Introduced	Forb/herb	0.9	0.10
<i>Cytisus scoparius</i>	Introduced	Shrub	0.7	1.80
<i>Dactylis glomerata</i>	Introduced	Graminoid	5.45	0.33
<i>Danthonia californica</i>	Native	Graminoid	0	0.35
<i>Daucus carota</i>	Introduced	Forb/herb	4.75	3.07
<i>Elymus glaucus</i>	Native	Graminoid	10.1	0.00
<i>Festuca arundinacea</i>	Introduced	Graminoid	9.9	13.33
<i>Festuca spp.</i>	Introduced	Graminoid	0.6	3.27
<i>Fragaria virginiana</i>	Native	Forb/herb	0	5.92
<i>Frangula</i>	Native	Tree, Shrub	0	0.10
<i>Galium aparine</i>	Native	Vine, Forb/herb	3.8	1.86

<i>Hedera spp.</i>	Introduced	Vine, Forb/herb	0.1	0.00
<i>Holcus lanatus</i>	Introduced	Graminoid	1.7	0.49
<i>Hypericum perforatum</i>	Introduced	Forb/herb	0	0.20
<i>Hypochaeris radicata</i>	Introduced	Forb/herb	0.75	13.33
<i>Lathyrus sphaericus</i>	Introduced	Forb/herb	0	0.10
<i>Leucanthemum vulgare</i>	Introduced	Forb/herb	0.7	0.20
<i>Lupinus oreganus</i>	Native	Forb/herb	0	1.77
<i>Luzula campestris</i>	Native	Graminoid	0.1	0.09
<i>Myosotis discolor</i>	Introduced	Forb/herb	0.1	0.00
<i>Parentucellia viscosa</i>	Introduced	Forb/herb	0.5	0.39
<i>Plantago lanceolata</i>	Introduced	Forb/herb	0.1	2.90
<i>Prunella vulgaris</i>	Native	Forb/herb	0	0.12
<i>Prunus spp.</i>	Introduced	Tree	0.1	0.00
<i>Pteridium aquilinum</i>	Native	Forb/herb	0.35	6.13
<i>Rosa spp.</i>	Native	Shrub	0.35	2.83
<i>Rubus armeniacus</i>	Introduced	Subshrub	2.35	2.57
<i>Rumex acetosella</i>	Introduced	Forb/herb	0	0.02
<i>Senecio jacobaea</i>	Introduced	Forb/herb	0.35	0.03
<i>Sidalcea</i>	Native	Forb/herb	0	2.01
<i>Solidago canadensis</i>	Native	Forb/herb	0.3	0.00
<i>Spiraea douglasii</i>	Native	Shrub	9.5	0.07
<i>Taraxacum officinale</i>	Introduced	Forb/herb	0.2	0.03
<i>Vicia hirsuta</i>	Introduced	Vine, Forb/herb	0.55	0.66
<i>Vicia sativa</i>	Introduced	Vine, Forb/herb	3.85	1.99

APPENDIX J. COVER OF ALL SPECIES OBSERVED IN MONITORING PLOTS AT EAST SPIRES IN 2013

Species	US Nativity	Growth Habit	Ave	SE
<i>Acer macrophyllum</i>	Native	Tree, Shrub	0.17	0.17
<i>Achillea millefolium</i>	Native	Forb/herb	0.02	0.02
<i>Agrostis stolonifera</i>	Introduced	Graminoid	40.27	4.16
<i>Aira caryophyllea</i>	Introduced	Graminoid	3.43	1.14
<i>Alnus</i>	Native	Tree, Shrub	0.07	0.07
<i>Amelanchier alnifolia</i>	Native	Tree, Shrub	0.07	0.07
<i>Anthoxanthum odoratum</i>	Introduced	Graminoid	31.27	3.98
<i>Arrhenatherum elatius</i>	Introduced	Graminoid	8.53	1.68
<i>Bromus carinatus</i>	Introduced	Graminoid	0.17	0.12
<i>Bromus hordeaceus</i>	Introduced	Graminoid	0.00	0.00
<i>Bromus sterilis</i>	Introduced	Graminoid	0.00	0.00
<i>Centaureum erythraea</i>	Introduced	Forb/herb	0.03	0.03
<i>Clarkia amoena</i>	Native	Forb/herb	0.03	0.02
<i>Convolvulus</i>	Native	Forb/herb	0.00	0.00
<i>Corylus sp</i>	Native	Tree, Shrub	0.07	0.07
<i>Crataegus douglasii</i>	Native	Tree, Shrub	0.07	0.04

<i>Crepis capillaris</i>	Introduced	Forb/herb	0.33	0.27
<i>Crepis setosa</i>	Introduced	Forb/herb	0.27	0.15
<i>Cynosurus echinatus</i>	Introduced	Forb/herb	0.28	0.18
<i>Dactylis glomerata</i>	Introduced	Graminoid	0.27	0.27
<i>Danthonia californica</i>	Native	Graminoid	0.37	0.18
<i>Daucus carota</i>	Introduced	Forb/herb	1.45	0.67
<i>Elymus glaucus</i>	Native	Graminoid	5.23	1.22
<i>Eriophyllum lanatum</i>	Native	Forb/herb	0.13	0.05
<i>Festuca arundinacea</i>	Introduced	Graminoid	12.57	3.70
<i>Galium parisiense</i>	Introduced	Forb/herb	0.82	0.32
<i>Holcus lanatus</i>	Introduced	Graminoid	0.34	0.18
<i>Hypericum perforatum</i>	Introduced	Forb/herb	0.42	0.23
<i>Hypochaeris radicata</i>	Introduced	Forb/herb	13.45	2.75
<i>Leucanthemum vulgare</i>	Introduced	Forb/herb	0.41	0.22
<i>Lonicera hispidula</i>	Native	Tree, Shrub	0.13	0.13
<i>Lupinus oreganus</i>	Native	Forb/herb	2.35	1.64
<i>Luzula</i>	Native	Graminoid	0.03	0.02
<i>Parentucellia viscosa</i>	Introduced	Forb/herb	0.84	0.27
<i>Plantago lanceolata</i>	Introduced	Forb/herb	5.92	1.34
<i>Polystichum munitum</i>	Native	Forb/herb	0.00	0.00

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<i>Prunella vulgaris</i>	Native	Forb/herb	0.30	0.18
<i>Pteridium aquilinum</i>	Native	Forb/herb	4.19	2.81
<i>Quercus garryana</i>	Native	Tree, Shrub	0.11	0.07
<i>Rosa</i>	Introduced	Tree, Shrub	1.67	1.35
<i>Rubus armeniacus</i>	Introduced	Tree, Shrub	3.00	0.98
<i>Rumex acetosella</i>	Introduced	Forb/herb	0.50	0.21
<i>Sanguisorba minor</i>	Introduced	Forb/herb	0.24	0.12
<i>Senecio jacobaea</i>	Introduced	Forb/herb	0.13	0.09
<i>Sidalcea</i>	Native	Forb/herb	0.17	0.09
<i>Spirea</i>	Native	Tree, Shrub	0.17	0.17
<i>Vicia hirsuta</i>	Introduced	Forb/herb	1.22	0.73
<i>Vicia sativa</i>	Introduced	Forb/herb	2.58	0.89
<i>Vicia tetrasperma</i>	Introduced	Forb/herb	0.02	0.01
<i>Vulpia bromoides</i>	Introduced	Graminoid	0.07	0.07

APPENDIX K. PLANTING PROTOCOL

Planting areas

- Do not plant in previously seeded plots (see map, above).
- Do not plant within 30 feet of the site margin.
- Do not plant in heavy introduced grass
- Do not plant in existing Kincaid's lupine patch.
- Begin planting in areas with little or no established Roemer's fescue.

Planting protocol

- Plant *Danthonia* on 18" centers in areas with little or no grass
- Interplant grasses with masses of a single forb on 18" centers offset from grass plugs
- Aim for about 5 patches of each forb on 18" centers
- If you run out of grass plugs for bare zones, plant 2 forbs on offset 18" grids. If you run out of grass-free areas, plant grass **or** forbs on 18" centers in areas of relatively light fescue.

This should yield about half an acre of stubby cells, or nearly 0.4 acre with the overlap between grass and forb plugs.

APPENDIX L. SEED MIXES USED AT BIG SPIRES

Matrix overseed: Broadcast ~3 weeks post burn at Big Spires and in E Spires

Species	Symbol	Seeds/ft ²
<i>Achillea millefolium</i>	ACMI	3
<i>Clarkia amoena</i> var. <i>lindleyi</i>	CLAM	5
<i>Eriophyllum lanatum</i>	ERLA	10
<i>Gilia capitata</i> [new crop 2012]	GICA	5
<i>Prunella vulgaris</i> var. <i>lanceolata</i>	PRVU	5
<i>Bromus carinatus</i>	BRCA	5
<i>Elymus glaucus</i>	ELGL	5
<i>Festuca roemerii</i>	FERO	5
<i>Luzula comosa</i>	LUCA	5

Diversity plot seed mixes used at Big Spires.

		seeds/square foot
Seed mix "A"		
Farewell-to-spring	<i>Clarkia amoena</i> var. <i>lindleyi</i>	10
common yarrow	<i>Achillea millefolium</i>	5
bluehead gilia	<i>Gilia capitata</i>	10
large-flowered collomia	<i>Collomia grandiflora</i>	10
slender tarweed	<i>Madia gracilis</i>	10
western buttercup	<i>Ranunculus occidentalis</i>	5
sea blush	<i>Plectritis congesta</i>	21
small camas	<i>Camassia quamash</i>	15
Seed mix "B"		
giant blue-eyed Mary	<i>Collinsia grandiflora</i>	10
common yarrow	<i>Achillea millefolium</i>	5
large-flowered collomia	<i>Collomia grandiflora</i>	10
midget phlox	<i>Microsteris (Phlox) gracilis</i>	10
western buttercup	<i>Ranunculus occidentalis</i>	5
small camas	<i>Camassia quamash</i>	15

Super-cell planting March 2012

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<u>Growth form</u>	<u>Species</u>	<u># Plants</u>
Bunch grass	<i>Danthonia californica</i>	2206
Slender forb	<i>Dichelostemma congesta</i>	2842
Forb	<i>Geranium organum</i>	3225
Slender forb (at first)	<i>Iris tenax</i>	351
Forb	<i>Lomatium dissectum</i>	3060
Forb	<i>Potentilla gracilis</i>	3420
Robust forb	<i>Wyethia angustifolia</i>	<u>229</u>

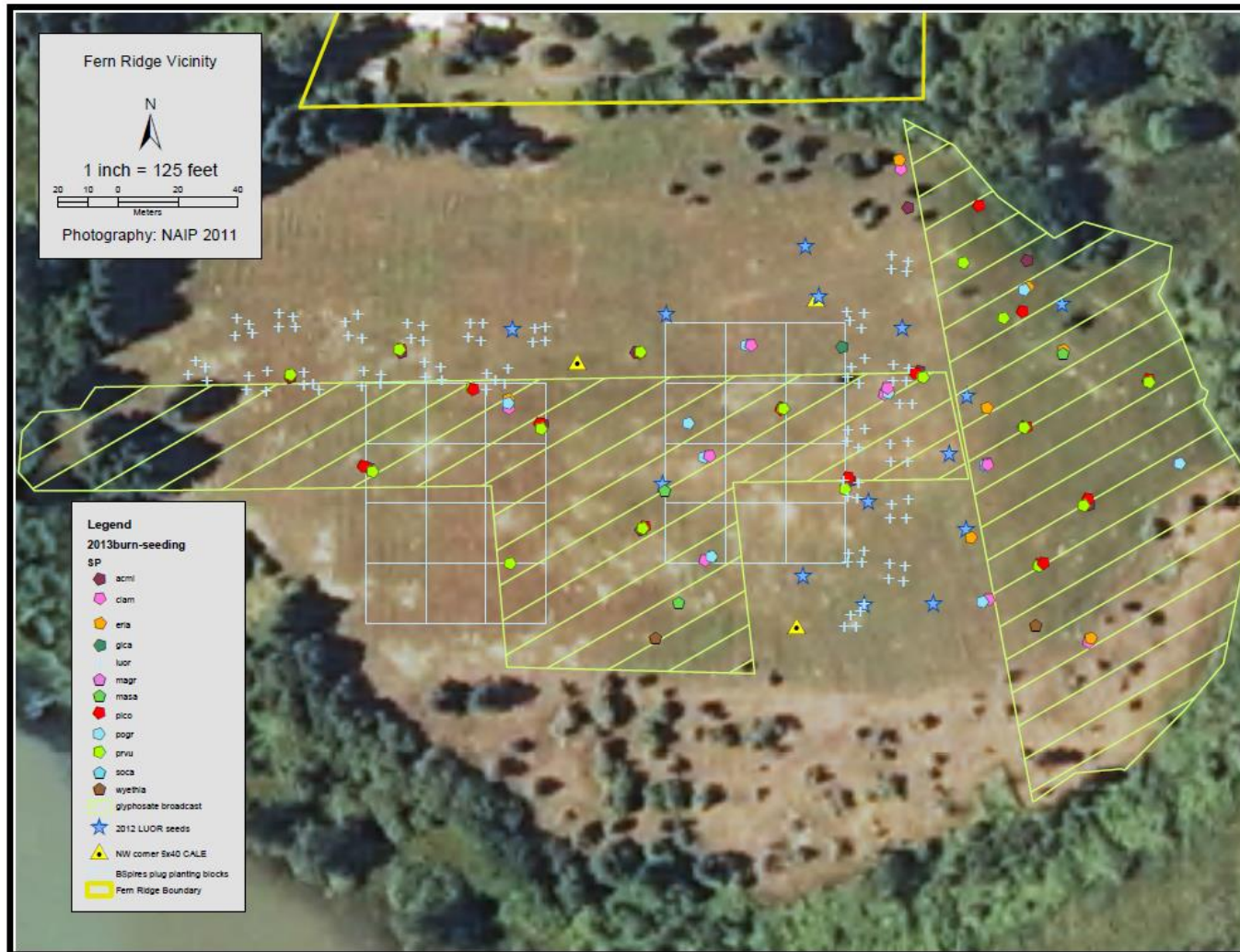


Figure 24. Planting schematic for 2013 post-burn seeding and planting