Practical solutions for managing Bradshaw's lomatium and wetland habitats

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Project Completion Report for OWEB Restoration Grant #213-3020-9793 and Effectiveness Monitoring Grant #213-3020-9994

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Institute for Applied Ecology

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PREFACE

IAE is a non-profit organization whose mission is conservation of native ecosystems through restoration, research and education. IAE provides services to public and private agencies and individuals through development and communication of information on ecosystems, species, and effective management strategies. Restoration of habitats, with a concentration on rare and invasive species, is a primary focus. IAE conducts its work through partnerships with a diverse group of agencies, organizations and the private sector. IAE aims to link its community with native habitats through education and outreach.

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Cover photographs: Wet prairie in bloom (May 2016) and Bradshaw's lomatium (top) just starting to flower at Cutler Lane. All photos by Andy Neill unless otherwise noted.

Special Note:
This report has been modified from its original format by removing maps and/or appendices that include information on the location of rare and sensitive species.

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1. PROJECT SUMMARY

Bradshaw's lomatium (*Lomatium bradshawii*) is a federally listed endangered plant that occurs in seasonally wet prairies in the Willamette Valley (ORBIC 2016). Habitat loss from farming, industrial and residential development, and altered flood regimes have dramatically reduced populations of this species. The Institute for Applied Ecology (IAE) worked with private landowners and managers to enhance 309 acres across three sites in the mid-and central Willamette Valley that currently host a population of Bradshaw's lomatium or have the potential to support this endangered species. Habitat restoration involved removing invasive plant species and improving native species diversity using traditional restoration techniques and modified agricultural practices. Flash grazing, a relatively new and evolving livestock technique, demonstrated the dual benefits to farmers and land managers of alternative biomass removal methods. Effectiveness monitoring documented the response of vegetation to the treatments, including the changes in population structure of Bradshaw's lomatium in grazed and ungrazed plots. Oregon Watershed Enhancement Board (OWEB) funds were used to remove invasive species, reduce encroaching woody plants, introduce and augment native wet prairie communities that benefit pollinators and other wildlife, and to monitor success. Partners in this project included two private landowners, McKenzie River Trust, U.S. Fish and Wildlife Service, and Cody Wood, owner of Willamette Valley Lamb.

2. BACKGROUND

The Willamette Valley spans 11,200 square miles and is home to some of Oregon's most valuable wetland, riparian, and biological resources. This ecoregion is also home to a thriving agricultural industry with nearly 360,000 acres in grass seed farms alone. Many native plant and animal communities have declined steadily over the last forty years, largely due to the tremendous loss and degradation of open prairie habitats. While only a small fragment of natural wetland and upland prairies remain, a wide array of partners are working together to restore these imperiled habitats.

Historically, agricultural and conservation lands have been at odds with each other as farms replace habitat with crops and conservation lands result in less acreage available for farmers. In addition, the federal listing of a number of endangered species can increase the amount of regulations governing actions on both public and private lands. However, we believe that working landscapes can in fact contribute significantly to regional conservation, providing multiple benefits to all Oregonians. Willamette Valley farmers have tools, resources, and knowledge that can make them allies in conserving Oregon's unique natural heritage. By working together, we can actively restore degraded habitat and

not only help recover endangered species, but potentially preclude the listing of additional species. A primary goal of this project is to adapt traditional agricultural techniques, specifically sheep grazing, to cooperatively restore habitat which will eventually aid in the removal of regulations that burden private landowners.

Since most of the land in the Willamette Valley is privately owned, meaningful conservation must go beyond public land management and engage private landowners. This project sought to enhance 309 acres of wet prairie and mixed forest habitat over three sites with the goal of restoring functional prairies capable of supporting at-risk plant species and wildlife species of conservation concern.

Managing prairies: Native wet prairies were historically maintained by natural and human-caused disturbances, primarily frequent burning. Following the removal of frequent burning across the landscape, woody plants and invasive species encroached on remaining prairie habitats have contributed to the decline of prairie abundance and quality, the loss of species diversity, and the listing of several species under the federal Endangered Species Act. While fire has been identified as a highly effective management tool for prairies in the Willamette Valley, its use in habitat management depends on numerous factors, including weather, site conditions and landowner and community support. These factors can make burning an unreliable tool because of planning complications, delays, and missed or partially effective treatments. Targeted livestock grazing can provide an additional management technique to control unwanted vegetation in areas where natural disturbance regimes have been altered due to fire suppression and hydrologic modifications. To date, prescribed grazing on restoration sites has been an underutilized habitat enhancement treatment in the Willamette Valley and only a handful of projects have looked at utilizing grazing as a management tool (Drew 2000, Giles-Johnson 2013, Ruggiero and Kral 2018).

Bradshaw's lomatium: The objective of the Recovery Plan for the Prairie Species of Western Oregon and Southwestern Washington (USFWS 2010) is to restore and maintain multiple functioning networks of each listed species across its historic range. Enhancing the habitat quality at sites with extant populations is expected to protect and stimulate expansion of Bradshaw's lomatium populations and meet the recovery objective of maintaining population networks. Bradshaw's lomatium (Figure 1) is an endangered plant species found in wet prairies in the Willamette Valley. Bradshaw's lomatium is considered to have a high potential for recovery, given that large scale production and seeding has already been demonstrated to be successful. In a two-year study of livestock grazing in a population of Bradshaw's lomatium in Linn County, Oregon, grazing had a positive effect on emergence of lomatium seedlings and had no effect on survival (Drew 2000).

Figure 1. Bradshaw's lomatium in flower (top) and maturing seed (bottom). (Photos: IAE Staff)

Grazing can reduce thatch and competition with existing vegetation by reducing standing above ground biomass (Drew 2000). When thatch accumulates, populations of voles and other small rodents explode, and plants of Bradshaw's lomatium become highly susceptible to herbivory (Drew 2000). This OWEB-funded project evaluated the outcome of prescribed grazing on two sites that currently host Bradshaw's lomatium and at another site that has wet prairie habitat appropriate for Bradshaw's lomatium.

This report summarizes work at three project sites in the Willamette Valley: Coyote Spencer Wetlands (CSW), Cutler Lane, and Sublimity Prairie (Table 1). The project was funded by two OWEB grants: Restoration Grant #213-3020 9793 provided funds for restoration, plant materials, and implementation of grazing in wet prairie habitat from June 2016 to June 2018 and Monitoring Grant # 213-3020 9994 funded two years of monitoring (May 2016 and May 2018) Bradshaw's lomatium habitat prior to and after two years of flash grazing. These two grants also funded pre-treatment monitoring at six National Resource Conservation Services (NRCS) Wetland Reserve Program (WRP) sites that were dropped from the project and replaced with new sites. Cutler Lane was included in the original list of sites and Sublimity and Coyote Spencer Wetlands were added to the project.

Table 1. Three sites selected for habitat enhancement.

Project Site	County	Project Acres	Ownership
Coyote Spencer Wetlands*	Lane	190	Land Trust – McKenzie River Trust
Cutler Lane*	Benton	110	Private – Green Spring Farms
Sublimity Prairie	Marion	9	Private – Jack and Coralee Frauendiener

**Sites with natural populations of Bradshaw's lomatium.*

2.1. Project Objectives

The purpose of this project is to demonstrate innovative solutions for enhancing wetland habitats that support threatened and endangered species in the Willamette Valley, ultimately increasing their ecological values while reducing the long-term cost of management at project sites.

The objectives of this project were to

- Integrate traditional restoration techniques with sheep grazing to enhance and restore existing Bradshaw's lomatium habitat at three project sites in the Willamette Valley.
- Examine the effects of grazing on Bradshaw's lomatium habitat at two project sites with Bradshaw's lomatium and one without.

2.2. Project Sites

This habitat enhancement project was implemented in the Central and Southern Willamette Valley, Oregon (Table 1 and Figure 2). Ultimately, the three project sites were located in Marion, Linn and Lane counties, on properties with wetland habitat that supports pollinators, migratory birds and other wildlife. This project was originally designed to evaluate the outcome of prescribed grazing and habitat enhancement on seven sites enrolled in the Natural Resources Conservation Service Wetland Reserve Program (NRCS WRP). However, due to changes in the partnership with the NRCS, these seven sites were not included in the final implementation of this project and three new sites were selected as substitutes:

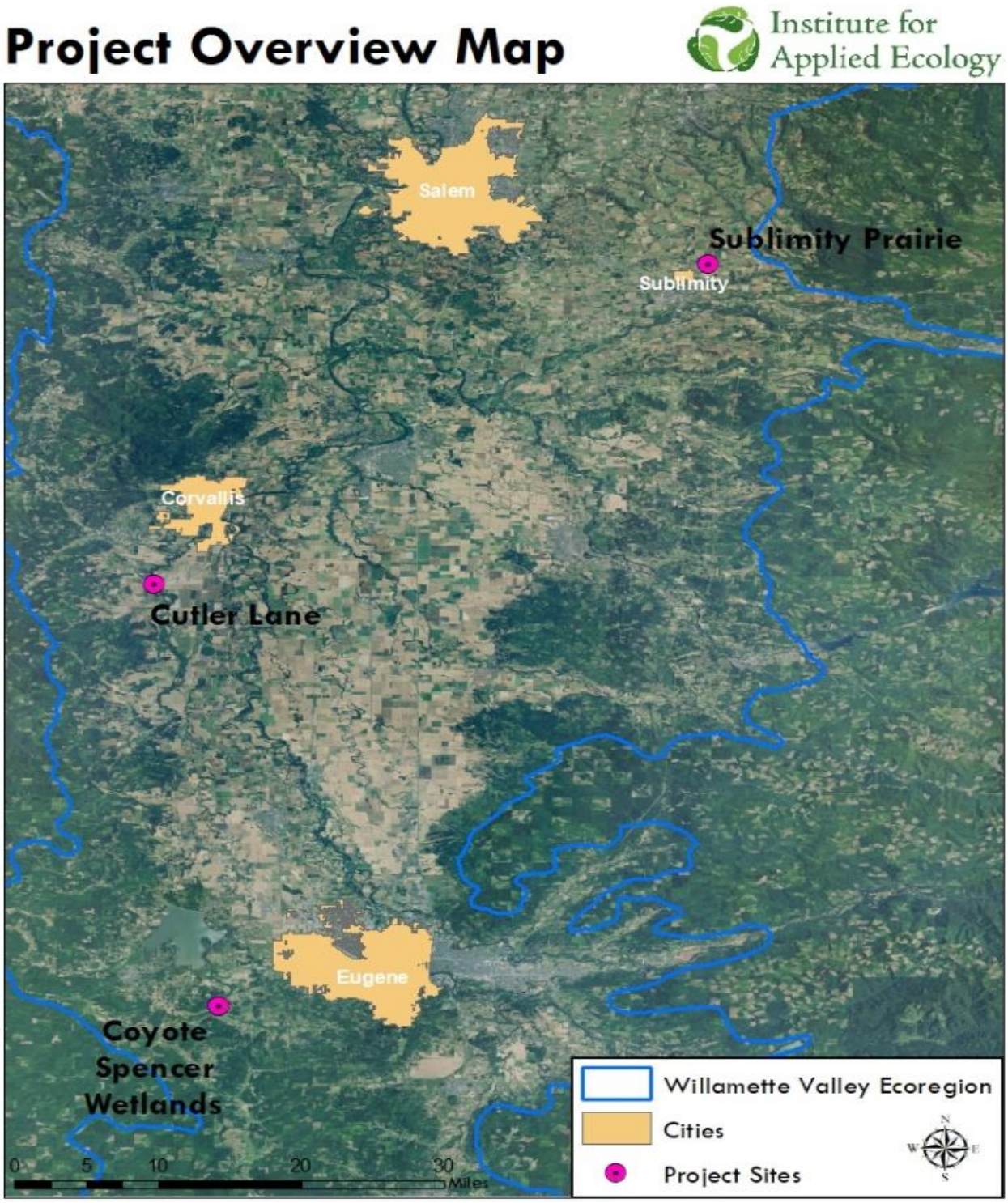

Figure 2. Project overview of the three project sites in the Willamette Valley.

Cutler Lane, Sublimity Prairie and CSW (Figure 2). Only Cutler Lane and CSW have existing Bradshaw's lomatium populations. Although Sublimity Prairie has suitable Bradshaw's lomatium habitat and Bradshaw's lomatium is located on an adjacent property, no Bradshaw's lomatium is known to occur at this project site. Sublimity Prairie is privately owned with no conservation easements. Of the three project

sites, only CSW, owned and managed by McKenzie River Trust, is managed primarily for habitat conservation. The Cutler Lane project area is part of a certified organic farm owned by Green Spring Farms, a farm management company. However, Cutler Lane has been involved in the U.S. Fish and Wildlife Service Partners for Fish and Wildlife Program (PFW) in the past with the goal of enhancing the existing Bradshaw's lomatium habitat and increase the size of the population at the site to aid in the recovery of this endangered species. The Sublimity Prairie site is not currently being actively managed; however, the Bonneville Power Administration periodically manages shrubs and trees under a powerline that crosses over wet prairie at the site. In addition to ownership, there are several factors that influence the management decisions at each site, including restricted use of herbicides at Cutler Lane and differences in native and weed plant communities between sites.

Coyote Spencer Wetlands

Lat. 44°0.7667' Long. 123°15.15.8667' Legal: T18S R5W Sec11, 14

Coyote Spencer Wetlands (CSW) is a 190-acre property owned and managed by the McKenzie River Trust (MRT). The goal of the MRT is to conserve and enhance the mixed and riparian forest, oak woodland, and upland and wet prairie habitats found on the property (Figure 3). CSW is located in the Long Tom watershed, at the confluence of Coyote and Spencer Creeks. There are over three miles of streams running through this site. The exceptional variety of native plants on the property can be found in few other places in the Willamette Valley. However, the habitat quality of this site, and its population of Bradshaw's lomatium, are threatened by the invasion of non-native grasses, primarily meadow foxtail (*Alopecurus pratensis*) and some reed canarygrass (*Phalaris arundinacea*), and the encroachment of woody plants such as Nootka rose (*Rosa nutkana*), Douglas' spirea (*Spiraea douglasii*), Himalayan blackberry (*Rubus bifrons*), Oregon ash (*Fraxinus latifolius*), domestic pear (*Pyrus communis*), and English hawthorn (*Crataegus monogyna*) into the wet prairie and upland habitats

Figure 3. Aerial photo of the 373 acre Coyote Spencer Wetlands project site. (*Figure removed to protect location of endangered species*)

that were traditionally maintained as open prairie by periodic fires. Threats to other high value native habitats at the CSW include the encroachment of Oregon ash, domestic pear and English hawthorn into stands of large, open-grown Oregon white oak (*Quercus garryana*). These native oaks could continue to lose lower limbs if they are not released by removal of encroaching trees. The conservation status, location, and diverse habitats and plant communities present make CSW an ideal location for habitat enhancements to support the Bradshaw's lomatium population at the site.

Cutler Lane

Lat. 44°29.172' Long. 122°19.663' Legal: T12S R5W Sec32

Cutler Lane is a privately-held working farm that contains certified organic pasture and agricultural land adjacent to Muddy Creek (Figure 4). The 110-acre project site has wet prairie and mixed forest habitats and hosts several state and federally listed plant species, including Bradshaw's lomatium, thin-leaved peavine (*Lathyrus holochlorus*), Nelson's checkermallow (*Sidalcea nelsoniana*) and Willamette daisy (*Erigeron decumbens*). The wet prairie at Cutler Lane, where the majority of the Bradshaw's lomatium occurs, is considered too wet for agricultural crops and has primarily been used to graze sheep and cows annually during late spring and summer months. These grazing practices, as well as the limited use of

Figure 4. Aerial photo of the Cutler Lane project site. (*Figure to protect location of endangered species*)

herbicides, has preserved much of the wet prairie habitat and the population of Bradshaw's lomatium that is concentrated along a ditch that runs north and south through the middle of the meadow (Figure 4). The primary threats to the Bradshaw's lomatium habitat at Cutler Lane include invasive grasses such as reed canarygrass and meadow foxtail and encroachment of woody plants such as Nootka rose, snowberry (*Symphoricarpos albus*) and Oregon ash. Other threats to native habitats at the Cutler Lane include encroachment of Oregon ash, sweet cherry (*Prunus avium*) and English hawthorn into stands of large Oregon white oak with the growth form characteristic of trees grown in the open (i.e. having large lower limbs). Because Cutler Lane is an organic farm, herbicides not certified as organic could not be used to control vegetation anywhere on the property.

Sublimity Prairie

Lat. 44°50.4833' Long. 122°45.9167' Legal: T8S R1W Sec26

Sublimity Prairie (Figure 5), a privately-owned 9-acre site with remnant wet prairie just northeast of Sublimity, Oregon. The site has a diverse plant community on high-quality wet prairie habitat. Although the wet prairie is suitable for Bradshaw's lomatium, this species has not been observed at this property

Figure 5. Aerial photo of the Sublimity Prairie project site. (*Figure removed to protect location of endangered species*)

despite its presence on adjacent property to the southwest (Figure 5). Threats to the prairie include encroachment of woody species such as Oregon ash, English hawthorn, sweet cherry (*Prunus avium*), black locust (*Robinia* pseudoacacia), Scotch broom (*Cytisus scoparius*), Himalayan blackberry, as well as the invasion of non-native forbs and grasses such as tansy ragwort (*Jacobaea vulgaris*) and creeping velvetgrass (*Holcus mollis*). Restoration at Sublimity Prairie was an excellent opportunity to improve and expand high quality wet prairie at the very northern extent of the regional distribution of Bradshaw's lomatium.

3. PROJECT DESCRIPTION

Habitat restoration and the grazing study were implemented over three years (from 2016 to 2018) at the three project sites. Complete restoration schedules are summarized for each of the sites in Table 2. Spot spray herbicide treatments typically occurred in late spring and summer, shrub and tree treatments typically occurred in the summer to early fall, and planting and seeding of natives were completed in mid-fall to coincide with the start of the rainy season.

Table 2. Schedule of management actions that occurred at three project sites from 2016 to 2018.

Site	Year	Date	Management Actions
Coyote Spencer Wetlands	2016	May 12	Installation and vegetation monitoring of grazing study plots.
		July 19-21	Grazing of 0.5 acre plot by sheep brought by Cody Wood. Hand pulling of tansy ragwort in grazing study plots. Deadheading of teasel, thistles, and tansy ragwort in Fields 2 and 3.
	2017	June 28	Project coordination, site visit and photopoints
		July 17-20	Grazing of 0.5 acre plot by sheep brought by Cody Wood. Hand pulling of tansy ragwort in grazing study plots.
		August 9	Spot Spray shrubs and thistles.
		August 22	Contract spray crew targeted shrubs in meadows and hack and squirt of pear and English hawthorn in prairie, forest and oak woodland habitats.
		October 12	Mowed ~0.25 acre to reduce thatch for glyphosate application.
		October 23	Sprayed grasses with glyphosate on ~0.25 acre test plot.
		November 7	USFWS mowed meadows targeting grasses and shrubs treated in September.
		November 14	Broadcast native seed mix on grazing study plots, herbicide test plot and bare soil in treated and mowed meadows.
		November 29	Pick up plants from supplier.
		Nov. 30-Dec 1	Planting native plants with volunteers and McKenzie River Trust.
		December 19	Site visit and project coordination with McKenzie River Trust.
	2018	June 4	Site visit and photopoint collection.
		June 15	Contract crew hack and squirt female ash, pear and English hawthorn at edge of meadows and in mixed forest.

Site	Year	Date	Management Actions
		June 21	Chainsaw crew felled and piled pear in and around meadows. Treated stumps. Released oak trees by cutting and piling ash and small oaks from around larger oaks. Piled trees in small burn piles and covered in plastic to be burned by McKenzie River Trust in fall 2018.
		June 25	Contract crew weed wiped sprouting Nootka rose and spirea in project meadows that were treated in late-summer 2017.
Cutler Lane	2016	March 1-2	Project coordination and site visit with farm manager.
		April 4	Survey of Bradshaw's lomatium and established grazing study plots.
		April 7-18	Four days to build exclosure fence around grazing study plot.
		May 3	Used brush cutter to cut Nootka rose and small Oregon ash. Piled material.
		May 10	Vegetation monitoring of grazing study plots and brush-cutting and piling of Nootka rose.
		September 21	Used brush-cutter to cut Nootka rose and small Oregon ash. Piled material.
		October 5	Used chainsaw to cut and pile Oregon ash and hawthorn in meadow near Bradshaw's lomatium.
	2017	June 28	Site visit to assess grazing and take photopoints.
		July 11	Site visit and project coordination with farm manager to discuss fall 2017 restoration actions.
		July 21	Site visit and project coordination with farm manager to map out fall 2017 restoration actions.
		Sept. 11-12	Used brush-cutter to cut Nootka rose and small Oregon ash. Piled material.
		September 22	Mapped and marked Oregon ash, English hawthorn, and non-native sweet cherry to release Oregon white oak in mixed forest near Bradshaw's lomatium.
		October 12	Farm manager used skid steer to mow ~2.5 acres in Bradshaw's lomatium habitat to remove shrubs and small ash.
		October 26	Contract crew used chainsaws to release Oregon white oak by cutting Oregon ash, English hawthorn, and non-native sweet cherry trees near Bradshaw's lomatium. Broadcast native seed mix on grazing study plots.
		November 9-17	Four days of planting native plants with volunteers and seeding with belly seeders.
	2018	May 15	Survey of Bradshaw's lomatium in grazing study plots.
		June 20	Removed exclosure fence from grazing study plot.

Site	Year	Date	Management Actions
Sublimity Prairie	2016	March 7	Site visit and coordination with landowner.
		May 11	Vegetation monitoring of grazing study plots.
		July 20	Site visit and project coordination with landowner and neighbors to facilitate sheep loading and unloading. Hand pulling of tansy ragwort in grazing study plots.
		July 25-27	Grazing of 0.5 acre plot by sheep brought by Cody Wood. Hand pulling of tansy ragwort in grazing study plots.
		July 27	Site visit and photopoints with sheep in grazing study plot.
		September 15	Spot spray Scotch broom and Himalayan blackberry. Hack and squirt ash and English hawthorn in prairie.
	2017	June 27	Site visit, photopoints and project coordination with farmer to confirm access to prairie.
		June 29	Spot spray thistle, Scotch broom, tansy ragwort and Himalayan blackberry. Hand pulling of tansy ragwort in grazing study plots.
		July 24-27	Grazing of 0.5 acre plot by sheep brought by Cody Wood.
		October 9	Mowed grasses near grazing study plots to remove thatch.
		October 23	Sprayed grasses with glyphosate in test plot near grazing study plots to kill grass.
		December 7	Broadcast native seed mix and planted showy milkweed in grazing study plots. Broadcast seed in areas previously targeted with spot spray herbicide applications.
	2018	May 31	Spot spray herbicide application to tansy ragwort, Himalayan blackberry, and Scotch broom.

3.1. Habitat Restoration

Coyote Spencer Wetlands

Grazing: Although this project began in 2016, management actions at CSW, such as mechanical or chemical weed control, did not begin until 2017. This was due to delays associated with weed and native plant surveys that were required to fulfill a Department State Lands request related to the purchase of CSW by MRT. Vegetation surveys of the area that included the grazing plots needed to be completed prior to implementation of the grazing study (Figure 3). CSW is a protected site and MRT is engaged in ongoing efforts to secure funding to continue restoration of the site beyond the scope of this project.

Cody Wood, owner of Willamette Valley Lamb, installed a temporary fence and herded 100 sheep into the enclosure for three days starting on July 19, 2016 and again on July 17, 2017 (Figure 6). Cody brought non-lactating ewes because the forage quality was too low for lactating ewes to produce quality milk for lambs. The sheep were confined to the enclosure for about 11 hours a day and herded into a smaller pen at night as protection from predators (Figure 7). In the grazed plot at CSW, the sheep tended to spend more time near the water trough and in the northeast corner where there was shade from trees rooted outside of the study plot. The extra time spent by sheep in these areas resulted in less thatch and more bare ground that lasted into the fall when seeding took place (Figure 6).

Figure 6. A shallow ditch in the grazed Coyote Spencer Wetlands study plot near where the water trough was placed for the sheep in August 2017 (left) and October 2017 (right).

Figure 7. Temporary electrical fence and sheep on the grazed study plot at the Coyote Spencer Wetlands site (left, July 2017) and nighttime pen and trailer for sheep (right, July 2016).

Invasive species control: IAE worked closely with MRT staff to ensure the management actions at CSW correspond with long-term management goals for the site. A temporary restriction of herbicide use at CSW limited invasive species management to control of grasses and forbs by hand in 2016. Within the Bradshaw's lomatium habitat at CSW, meadow foxtail is the most abundant non-native species of concern (Figure 8). Long-term treatment would require a series of herbicide applications over multiple years; however, this timeframe was beyond the scope of this project, and we recommend control of the meadow foxtail as a high-priority future action at the site.

Figure 8. Meadow foxtail dominating Bradshaw's lomatium patch in Field 3 at Coyote Spencer Wetlands in 2016.

In the shorter-term, we focused on manual removal of flowers and seed heads of thistles, tansy ragwort and teasel (*Dipsacus fullonum*) in Fields 2 and 3. Flowers and seed heads were clipped, bagged and removed from the site to reduce seed production of these problem weeds. In August 2017, herbicide treatments by IAE staff targeted thistles and Himalayan blackberry within and along the perimeter of Field 3. During the same month a contract crew used a hack-

Figure 9. Domestic pear treated with herbicide using a hack and squirt method at Coyote Spencer Wetlands.

and-squirt method to kill domestic pear and English hawthorn in the forest edge around Field 3 and in the riparian forest and oak woodland habitats between Field 3 and Crow road at the eastern edge of the property (Figure 9). At the same time, the contractor crew used backpack sprayers to apply herbicide to shrubs in wet prairie habitat of Fields 3 and 4 (Figures 10 and 11). The effects of the herbicide applications were noticeable within a couple of weeks. In mid-October of 2017, USFWS mowed Fields 3 and 4, which included both the grazing study plots and the shrubs and small trees in the meadows that were treated with herbicide in August of that year. The mower reduced the height of large patches of shrubs to ground level and exposed sizable patches of bare soil in the two fields (Figure 12).

Figure 10. Coyote Spencer Wetlands photopoint 3 in the grazed study plot in Field 3 showing Nootka rose before (left) and after (middle) herbicide treatment and in spring 2018 (right) after being mowed in fall 2017.

Figure 11. Coyote Spencer Wetlands photopoint 3 in Field 4 with shrubs before (left) and after (middle) herbicide treatments in 2017 and in spring 2018 (right) after being mowed in fall 2017.

In June 2018, contract crews completed another hack-and-squirt herbicide application, used chainsaws to fell and pile trees, and used hand held weed wipers to wipe regenerating shrubs. The hack-and-squirt herbicide application focused on control of female Oregon ash at the edge of Fields 2, 3 and 4, as well as in the oak woodland between the northern portion of Field 3 and Crow road along the eastern edge of the property. Female Oregon ash trees were targeted to reduce the dropping of seed into the wet

prairie habitat. The contract crew also completed a second round of hack-and-squirt to kill any domestic pear and English hawthorn that were missed by or survived the herbicide treatment in 2017.

A contract sawyer crew felled and piled domestic pear and English hawthorn in and around Field 4. Large Oregon white oak along the perimeter of northern portion of Field 4 were released by felling and piling Oregon ash and smaller oaks. Oregon white oak in remnant upland prairie patches in the Bloomer Field were released by felling and piling Oregon ash, English hawthorn and domestic pear under the dripline of the released oaks (Figure 13). The stumps of all felled trees were treated with herbicide to prevent resprouting. All of the piles were covered by plastic sheet and will be burned by MRT staff in fall 2018. Leftover seed will be broadcast to bare ground exposed after the piles are burned.

Figure 12. IAE Restoration Technician, Anna Ramthun using a belly seeder to broadcast native seed in bare areas of Field 4 at Coyote Spencer Wetlands after being mowed in fall 2017.

Figure 13. Oregon white oak released and treated stumps in the Bloomer Field at Coyote Spencer Wetlands (June 2018).

On June 25, 2018, a contract crew used hand held wipers to apply herbicide to Nootka rose, Himalayan blackberry and Douglas' spirea that was sprouting from surviving plants in Fields 3 and 4. Weed wipers were used to avoid killing natives growing with the shrubs (Figure 14).

A quarter acre test plot near the access road in Field 3 that is dominated by meadow foxtail was mowed in October and sprayed with glyphosate 11 days later. This was done to assess the response of meadow foxtail to these traditional restoration techniques and prepare the site for planting and seeding in fall 2017. The mowing reduced the height of the thatch to provide better herbicide coverage to the growing grasses but did not reduce thatch enough to facilitate the establishment of seeded natives. Additional herbicide applications would be needed to control meadow foxtail growing in the plot and thatch would need to be raked or burned to access the soil surface to increase the success of seeding.

Figure 14. Resprouting shrub and flowering forbs in Field 4 prior to weed wiping (left) and handheld weed wiper wiping Nootka rose (right) at Coyote Spencer Wetlands (June 2018).

Seeding and planting: Native seed mixes and planting schemes used to augment wet prairie habitat at CSW in 2017 focused on species characteristic of wet prairies in the Eugene West recovery zone (Tables 3 and 4). More specifically, species were selected that would improve wet prairie habitat for Bradshaw's lomatium. Grasses were excluded from the mix to maintain the option to control non-native grasses, especially meadow foxtail, at the site with grass specific herbicides in the future (Table 3). All native seed was broadcast using belly seeders on to the grazing study plots and grass treatment assessment plot in Field 3 and bare ground exposed after fall mowing in Fields 3 and 4 (Figure 12). Planting of bare-root, bulbs and plugs (Table 4) was completed by IAE and MRT staff and volunteers over two days in fall 2017 (Figure 15). In addition to the grazing study and test plots, planting areas included bare spots after fall mowing o Fields 3 and 4 as well as around patches of Bradshaw's lomatium (Figure 3). Some of the seeded and planted natives were observed flowering in both Fields 3 and 4 where the shrubs had been treated and mowed (Figure 14) and in the grazing study plots (Figure 16).

Table 3. Native seed mixes broadcast at Coyote Spencer Wetlands in 2017.

			Pounds/acre	
Scientific Name	**Common Name**	**Growth Form**	**Meadow (3 ac)**	**Grazing Study Plots (1 ac)**
Acmispon americanus	American bird's-foot trefoil	Forb	0.25	0.25
Camassia leichtlinii var. suksdorfii	tall camas	Forb	0.25	0.25
Carex densa	dense sedge	Sedge	0.20	0.20
Carex pachystachya	chamisso sedge	Sedge	0.20	0.20
Carex tumulicola	splitawn sedge	Sedge	0.20	0.20
Carex unilateralis	one-sided sedge	Sedge	0.20	0.20
Deschampsia cespitosa	tufted hairgrass	Grass	0.90	0.90
Downingia elegans	elegant calicoflower	Forb	0.40	0.40
Epilobium densiflorum	denseflower willowherb	Forb	0.20	0.20
Eriophyllum lanatum	woolly sunflower	Forb	0.25	0.25
Geum macrophyllum	large-leaved avens	Forb	0.20	0.20
Hordeum brachyantherum	meadow barley	Grass	0.30	0.30
Madia glomerata	cluster tarweed	Forb	0.25	0.25
Plagiobothrys figuratus/ scouleri mix	fragrant and Scouler's popcorn flower mix	Forb	0.25	0.25
Potentilla gracilis	slender cinquefoil	Forb	0.17	0.17
Poteridium occidentale	western burnet	Forb	0.15	0.15
Prunella vulgaris var. lanceolata	common selfheal	Forb	0.25	0.25
Rumex salicifolius	willow dock	Forb	0.16	0.16

Scientific Name	Common Name	Growth Form	Pounds/acre	
			Meadow (3 ac)	Grazing Study Plots (1 ac)
Symphyotrichum hallii	Hall's aster	Forb	0.07	0.07
Thalictrum polycarpum	tall meadow-rue	Forb	0.30	0.30
		Total pounds per acre	5.14	5.14
		Total pounds	15.42	5.14

Table 4. Native species planted at Coyote Spencer Wetlands in 2017.

Scientific Name	Common Name	Growth Form	Size	Grazing Study Plots (x2)	Test Plot	Meadows	Total
Camassia quamash	common camas	Forb	Bulb	200	200	1900	2500
Carex densa	dense sedge	Sedge	Plug	50	50	250	400
Dodecatheon hendersonii	broad-leaved shooting star	Forb	Bare-root	50	50	350	500
Eleocharis palustris	creeping spikerush	Sedge	Bare-root	100	100	700	1000
Sidalcea cusickii	Cusick's checkermallow	Forb	Bare-root	50	50	300	450
Sisyrinchium idahoense	Idaho blue-eyed grass	Forb	Bare-root	150	150	2050	2500
Thalictrum polycarpum	tall meadow-rue	Forb	Bare-root	25	25	175	250
			Total planted	**625**	**625**	**5725**	**7600**

Figure 15. Volunteers at Coyote Spencer Wetlands planting natives in the grazing study plots (left) and common camas bulbs and tall meadow-rue about to be planted (right) (Photos: Dean Walton, volunteer).

Figure 16. Planted Cusick's checkermallow (left), seeded popcorn flower (middle) and Bradshaw's lomatium seed with common camas (right) in the grazed study plot in Field 3 at Coyote Spencer Wetlands.

Figure 17. Grazed wet prairie habitat at Cutler Lane (September 2016).

Cutler Lane

The Cutler Lane project site (Figure 4) is part of an organic farm where the use of conventional herbicides is not permitted to control vegetation. Certified organic herbicides have been used in the past to control annual grasses at this site, but high cost of these herbicides prohibit their use at a larger scale.

Grazing: This site has a history of grazing by both sheep and cattle. The current and previous land owners utilized annual grazing by sheep from ~June through November (Figure 17). At the initiation of this study, vegetation in both plots consisted of relatively low statured water foxtail (*Alopecurus geniculatus*) with smaller amounts of meadow foxtail and reed canary grass (Figure 18). Although sheep and cows have grazed the meadow in the past, only sheep grazed the field in 2016 and 2017. In spring 2016, a fence was built around a half-acre test

Figure 18. Construction of an exclosure to prevent grazing in Bradshaw's lomatium (flags) habitat at Cutler Lane (May 2016).

Figure 19. Comparison of grazed and un-grazed areas outside and inside of the exclosure (left) and sheep in the meadow at Cutler Lane (right) (September 2017).

plot to exclude sheep (Figures 18 and 19). Grazing for the grazed plots in 2016 and 2017 followed the standard grazing protocol for the site in which grazing in the wet prairie begins in early June when the river levels are low enough to access the field and forage values are better than other pastures that are grazed near the project area. This usually coincides with senescence of several native wet prairie species and maturation of seed including Bradshaw's lomatium plants (Figure 20). Thus the grazed plots at Cutler Lane differ from the other sites in that the grazed plots have been continually grazed for many years, and the ambient grazing regime was excluded in the ungrazed plot. At the other sites, grazing has not been part of recent land use actions at the sites.

Figure 20. Effects of annual grazing in September 2016 (top-left), June 2017 (top-right) and September 2017 (bottom-right) in the meadow at Cutler Lane with Bradshaw's lomatium seed with sheep dropping (inset).

Invasive Species and Woody Plant Control: The primary method to control non-native vegetation in the wet prairie was grazing coordinated by Green Spring Farm staff as part of their normal grazing regimen.

Grazing of the meadow by sheep began in early June and ended in mid-October in 2016 and 2017 (Figures 20 and 21). This timing allowed Bradshaw's lomatium seed to ripen and plants to senesce. The grazing reduced thatch and exposed patches of bare soil (Figure 20).

Shrubs and trees in the Bradshaw's lomatium habitat were cut using brush cutters and chainsaws and piled in spring and summer of 2016 and 2017 (Figure 21). Although some shrubs and trees did die, many re-sprouted the following year. The growing tips of the resprouting shrubs were browsed by animals grazing in the meadow which aided in the control of these species (Figure 22). Without chemical control it is likely that annual cutting for several years would be needed to sufficiently suppress woody species at Cutler Lane.

Figure 22 Nootka rose before (top) and after (bottom) brushcutting in the meadow at Cutler Lane (May 2016).

Figure 21. Resprouting Oregon ash (left) and Nootka rose (right) showing signs of browsing after being cut one year prior at Cutler Lane (September 2017).

Oregon ash, sweet cherry, and English hawthorn were felled and bucked to release large, open-grown Oregon white oak in the meadow and oak woodlands at Cutler Lane in October 2017 (Figure 23). Stumps were cut as close to the ground as possible but not treated with herbicide to prevent re-sprouting.

Figure 23. Oregon white oak before (left) and after (right) release from Oregon ash and English hawthorn trees in Bradshaw's lomatium habitat (October 2017) at Cutler Lane.

Seeding and Planting: Native seed mixes and planting schemes used to augment wet prairie habitat at Cutler Lane in 2017 focused on species characteristic of wet prairies in the Corvallis West recovery zone (Tables 5 and 6). More specifically, species were selected that would improve wet prairie habitat and not create conditions that would inhibit growth and reproduction of Bradshaw's lomatium. Grasses were included in the mix to increase competition with non-native grasses at the site and improve diversity (Table 5). All native seed was bulked up with inert rice hulls and broadcast using belly seeders on to the grazing study plots and across the meadow (Figure 24). Bare ground exposed by grazing in the meadow but outside of the grazing study plots was targeted with a slightly higher seeding rate to increase establishment rate of seeded plants. In the summer of 2017, a pipe was installed along the length of the southern edge of the meadow. This created a five meter wide strip of bare soil. Blue wildrye (*Elymus glaucus*) and tall camas (*Camassia leichtlinii* var. *suksdorfii*) were seeded and 1,500 tall camas bulbs were planted in this strip. Areas adjacent to the meadow that were thinned to release Oregon white oak were seeded with blue wildrye and tall camas. Planting of bare-root, bulbs and plugs (Table 6) in the meadow was completed by IAE staff and volunteers over four days in fall 2017 (Figure 25).

Table 5. Native seed mixes broadcast at Cutler Lane in 2017.

			Pounds/acre		
Scientific Name	**Common Name**	**Growth Form**	**Woodland (5.4 ac)**	**Meadow (7.2 ac)**	**Grazing Study Plots (1 ac)**
Agrostis exarata	spike bentgrass	Grass			2.01
Alopecurus geniculatus	water foxtail	Grass		2.72	5.00
Beckmannia syzigachne	American sloughgrass	Grass		2.33	
Camassia leichtlinii var. *suksdorfii*[1]	tall camas	Forb	3.31		
Carex densa	dense sedge	Sedge		1.47	
Carex stipata	saw-beaked sedge	Sedge		2.88	
Carex unilateralis	one-sided sedge	Sedge		1.11	
Deschampsia cespitosa	tufted hairgrass	Grass		2.26	2.70
Downingia elegans	elegant calicoflower	Forb		1.05	0.58
Eleocharis palustris	creeping spikerush	Rush		1.12	
Elymus glaucus	blue wildrye	Grass	4.14		
Epilobium densiflorum	denseflower willowherb	Forb		1.55	0.40
Eriophyllum lanatum	woolly sunflower	Forb		1.94	0.40
Glyceria occidentalis	northwestern mannagrass	Grass		3.56	0.60
Grindelia integrifolia	Puget Sound gumweed	Forb		2.02	
Hordeum brachyantherum	meadow barley	Grass		10.63	0.60
Plagiobothrys figuratus/ scouleri mix	fragrant and Scouler's popcorn flower mix	Forb		1.35	1.32
Potentilla gracilis	slender cinquefoil	Forb		1.05	
Prunella vulgaris var. *lanceolata*	common selfheal	Forb		2.22	
Ranunculus orthorhynchus	straightbeak buttercup	Forb			0.00
Poteridium occidentale	western burnet	Forb		1.72	0.39
	Total pounds per acre		1.4	5.7	14.00
	Total pounds		7.45	40.98	14.00

Table 6. Native species planted at Cutler Lane in 2017.

Scientific Name	Common Name	Growth Form	Size	Grazing Study Plots (x2)	Meadow	Total
Camassia leichtlinii var. suksdorfii[1]	tall camas	Forb	Bulb	-	1500[1]	1500
Asclepias speciosa	showy milkweed	Forb	Plug	-	200	200
Camassia quamash	common camas	Forb	Bulb	300	1900	2500
Carex densa	dense sedge	Sedge	Plug	100	300	500
Dodecatheon hendersonii	broad-leaved shooting star	Forb	Bare-root	100	300	500
Eleocharis palustris[2]	creeping spikerush	Sedge	Bare-root	-	1000[2]	1000
Ranunculus occidentalis	western buttercup	Forb	Bare-root	100	300	500
Sidalcea campestris	meadow checkermallow	Forb	Bare-root	50	350	450
Sisyrinchium idahoense	Idaho blue-eyed grass	Forb	Bare-root	200	1600	2000
Thalictrum polycarpum	tall meadow-rue	Forb	Bare-root	25	200	250
Triteleia hyacinthina	hyacinth brodiaea	Forb	Bulb	25	175	225
			Total planted	**900**	**7825**	**9625**

Figure 24. Native seed mixed with rice hulls to be broadcast onto grazing study plots, the meadow, and oak release areas (October 2017).

[1] Tall camas planted only in disturbed soil following pipe installation at meadow edge with ash forest.
[2] Creeping spikerush planted only in ditch in middle of meadow.

Figure 25. Institute for Applied Ecology staff and volunteers planting bulbs and bare-root plants (left) and showy milkweed plugs (right) (November 2017).

Sublimity Prairie

Sublimity Prairie is a privately owned remnant wet prairie sandwiched between agricultural fields in Marion County, Oregon (Figure 5). The shallow soils and water holding characteristics have prevented farming or extensive grazing of the wet prairie. There is a high diversity of wet prairie associated plant species at the site that bloom into the summer (Figure 26).

Figure 26. Sublimity Prairie with native wet prairie species in bloom in May 31 (left, Photo: Michelle Yasutake) and May 14 (right), 2018.

Grazing: Introduction of sheep to graze at Sublimity Prairie had hurdles associated with the location among crop fields and access to the prairie at the time of grazing. To get to the site, the shepherd unloaded the sheep on a neighbor's property, built a temporary fence and herded the sheep with dogs along a narrow path between two crop fields being farmed for bentgrass seed and wheat (Figure 27). Multiple discussions and site visits with the landowners, shepherd and farmer leasing the field were needed to ensure access and that crop damage would be limited. A large watering container was

driven to the site to provide water for the sheep. At night the sheep were corralled into a pen on the grazing study plot (Figure 28). The high intensity grazing at Sublimity Prairie visibly reduced the thatch and exposed bare ground immediately after grazing, though there were not changes in bare ground observed in May of 2018. Not long after the grazing native forbs resprouted in and around the grazed study plot (Figure 29), though there were not significant differences observed in forb cover between the grazed and ungrazed plots in 2018.

Figure 27. Narrow access to Sublimity Prairie made transporting sheep and water difficult when it came time to graze the site in July (April 2016).

Figure 28. Sheep, water tank, and night time paddock at Sublimity Prairie (July 2017).

Figure 29. Resprouting forbs in the grazed study plot at Sublimity Prairie include slender cinquefoil (left), tufted hairgrass (middle) and Canada thistle (right) (August 2016).

Invasive Species and Woody Plant Control: Spot spray herbicide treatments at Sublimity Prairie reduced shrub and tree encroachment into the wet prairie and targeted non-native forbs and grasses (Figure 30). Herbicide applications occurred when native forbs were done flowering, senesced and seeds had dropped/released. Hack-and-squirt herbicide applications reduced the abundance of Oregon ash, English hawthorn, sweet cherry and Scotch broom in and around the prairie. Spot spray herbicide applications killed Himalayan blackberry, Scotch broom, Nootka rose, thistles and tansy ragwort. In 2016 and 2017, prior to the grazing in July, tansy ragwort was pulled by hand inside the grazing study plots instead of treating with herbicides to prevent herbivory of this toxic plant by the sheep and to reduce sheep exposure to pesticides. Tansy ragwort that had already flowered at Sublimity Prairie was pulled or clipped by hand and removed from the site to prevent seed dispersal. Similar to CSW, a small (~0.25 acre) test plot in an area dominated by velvetgrass was mowed in October and sprayed with herbicide 14 days later. This was done to assess the effectiveness of this method at controlling velvetgrass prior to seeding and planting natives.

Figure 30. Spot spraying English hawthorn (left, August 2016), treated and clipped patch of tansy ragwort (middle, October 2017) and dead Scotch broom treated in Fall 2016 and 2017 at Sublimity Prairie (right, May 2018).

Seeding and Planting: Sublimity Prairie is a source site for collection of wild seed, which is then used to establish seed production fields or grow plugs for outplanting at restoration sites. Because this site serves as a source for native plant materials, there is a desire to maintain genetic purity of species found at this site in the Salem East recovery zone. We worked with Lynda Boyer, Native Plant Manager at Heritage Seedlings, Inc., to create a seed mix and planting scheme appropriate for Sublimity Prairie that would not compromise the genetic integrity of wet prairie species at the site. Plant materials originating from the Salem East recovery zone, including Sublimity Prairie, were selected (Tables 7 and 8). The mix and

planting scheme included species that were already present on the site as well as species that have not been observed. Seed was broadcast into the grazing study and mowed test plots as well as areas treated with herbicide in 2016 and 2017. In addition to broadcasting native seed, 100 plugs of locally sourced showy milkweed were planted by IAE staff in each of the two grazing study plots (Table 8).

Table 7. Native seed mixes broadcast at Sublimity Prairie in 2017.

			Pounds/acre	
Scientific Name	**Common Name**	**Growth Form**	**Meadow (0.5 ac)**	**Grazing Study Plots (1 ac)**
Agrostis exarata	spike bentgrass	Grass	0.09	0.09
Asclepias speciosa	showy milkweed	Forb	2.04	2.04
Carex tumulicola	splitawn sedge	Sedge	1.45	1.45
Clarkia purpurea ssp. *quadrivulnera*	winecup clarkia	Forb	0.13	0.13
Deschampsia cespitosa	tufted hairgrass	Grass	0.14	0.14
Eriophyllum lanatum	woolly sunflower	Forb	0.26	0.26
Grindelia integrifolia	Puget Sound gumweed	Forb	2.37	2.37
Leptosiphon bicolor	true babystars	Forb	0.08	0.08
Microseris laciniata	cutleaf silverpuffs	Forb	1.21	1.21
Perideridia oregana	Oregon yampah	Forb	0.73	0.73
Poa secunda	pine bluegrass	Grass	0.36	0.36
Sidalcea campestris	meadow checkermallow	Forb	3.45	3.45
		Total pounds per acre	12.32	12.32
		Total pounds	6.16	12.32

Table 8. Native species planted at Sublimity Prairie in 2017.

Scientific Name	**Common Name**	**Growth Form**	**Type**	**Grazing Study Plots (x2)**	**Total Planted**
Asclepias speciosa	showy milkweed	Forb	Plug	100	200
			Total planted	200	200

3.2. Effectiveness Monitoring

Plant community monitoring methodology

In May 2016, paired (grazed and ungrazed) monitoring plots were established at all three study sites. Plot dimensions varied by site, but the goal was to create two 0.5-1 acre plots at each site. Plot corners were marked with concrete markers pounded flush to the ground, and location information was collected with a handheld Garmin GPS Map 60CSx to aid in plot relocation.

The sampling scheme at each site was selected so that (1) the maximum amount of habitat would be sampled, (2) paired plots would have similar in size and general vegetation cover, and (3) at least 60 individuals of Bradshaw's lomatium were present in each plot (at the two sites where Bradshaw's lomatium is present).

The site vegetation cover and composition were monitored using a point-intercept sampling method. In May of 2016 and 2018. IAE vegetation monitoring crews of 3-4 individuals worked in pairs to quantify vegetation cover and ground cover classes. Within each paired plot, 40m or 50m-long (depending on the site, see "Study plot layout" section below) transects were laid out perpendicular to the baseline, spaced every three meters, with the first transect randomly located between 0-2 meters along the baseline. Intercept points were then located along each transect every two or three meters (depending on the site, see study plot layout section below). In each of the treatment plots at least 200 data points were collected per plot (Figure 31).

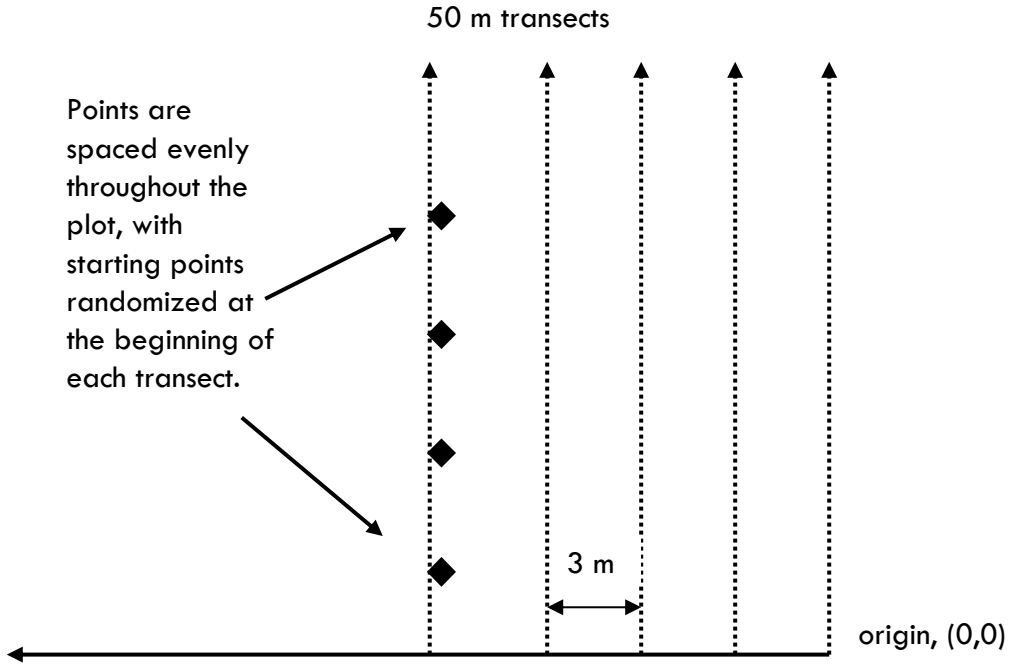

Figure 31. Example design of a sampling plot.

In order to record the species present at each intercept point, we used a monopod mounted with a laser purchased from Synergy Resource Solutions, Inc. We adjusted the height of the monopod so that it was greater than the height of the vegetation canopy at every site following methodology described by Elzinga et al. (2009). At each point the laser is held level, and we recorded the presence of every species intercepted by the laser light. Only the first intercept of a species by the laser light was counted. We also recorded the nature of the substrate (bare ground, litter, rock, or moss) at each point. Although a species could only be recorded once for each point, *post hoc* data analysis combined the species into plant management groups, and therefore those groups could be counted more than one time per point.

We calculated the percent cover within each plot by totaling the "hits" for each component (each species, and cover type), dividing by the total number of sampling points per plot, and multiplying by 100. Total cover for each plot was calculated by adding the percent cover of each component, and could exceed 100% due to multiple species intercepting the laser light at each point.

To calculate 95% confidence intervals, the following equation was used:

$$\sqrt{((n_1/n_2) * (1 - \left(\frac{n_1}{n_2}\right))/p) * 1.96}$$

Where n_1 = the number of hits for a species or plant management group, n_2 is the total number of vegetative hits, and p = number of points monitored.

We timed our surveys to document species that co-occur with *Lomatium bradshawii*, thus we may not have detected some very early or late season species. Species nomenclature, growth habit, and provenance were obtained from the USDA Plants Database (http://plants.usda.gov).

Study plot layout

COYOTE SPENCER WETLANDS

Two grazing study plots were established at CSW in the southwestern end of Field 3 (Figure 3).

The two 50m x 30m plots divide the meadow with the longer axis running roughly east-west (Figure 32). Monitoring transects were run roughly east/west, every 3m, with a random start between 0-2m (Figures 32 and 33). The plot origin in the southwest corner. Points were collected every 2m along the monitoring transects, with a random start of 0 or 1.

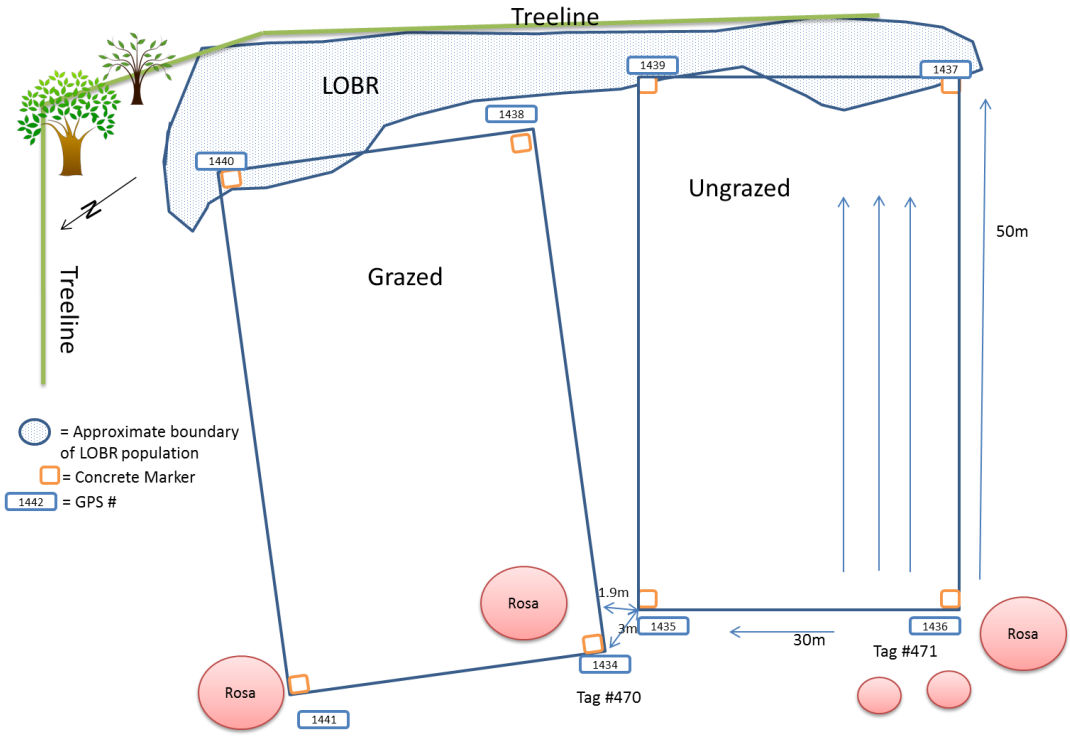

Figure 32. Schematic of plots at Coyote Spencer Wetlands.

Figure 33. Aerial photo of plots at Coyote Spencer Wetlands. North is towards the top of the page. Photo from Google Earth taken 5/29/16. Note that monitoring tracks from 5/12/16 are present in the photo.

CUTLER LANE

At Cutler Lane, a private organic farm which already experiences grazing by both sheep (and historically cattle), an exclosure was established to keep the ambient grazing from occurring in a portion of the population. Thus, the grazing regime on the grazed plots at this site have a longer and more intense grazing history, both before and during this experiment than at the other two sites. Ungrazed plots were removed from the ambient grazing regime beginning in the summer of 2016 by building a fenced exclosure in the south end of the grazed meadow (Figure 4). Monitoring transects were run roughly east/west, perpendicular to the north/south baseline (Figure 34). The first transect was placed

randomly between 0m and 2m along the baseline and then placed every 3m. Points were collected every 3m along the transect, with the first point on each transect randomly located from 0m-2m.

Figure 34. Aerial photo of plots at Cutler Lane. North is to the top of the page. The green area to the south is the exclosure where grazing was not allowed to occur. Photo from Google Earth, taken July 2016.

SUBLIMITY PRAIRIE

At Sublimity Prairie, the paired plots are each 40m x 50m with the longer axis running roughly north-south, and the origin in the northwest corner (Figure 35). There is a small patch of trees in the eastern plot (Figures 35 and 36). Monitoring transects were run roughly east/west, perpendicular to the north/south baseline. The first transect was placed randomly between 0m and 2m along the baseline and then placed every 3m. Points were collected every 3m along the transect with a random start from 0m-2m.

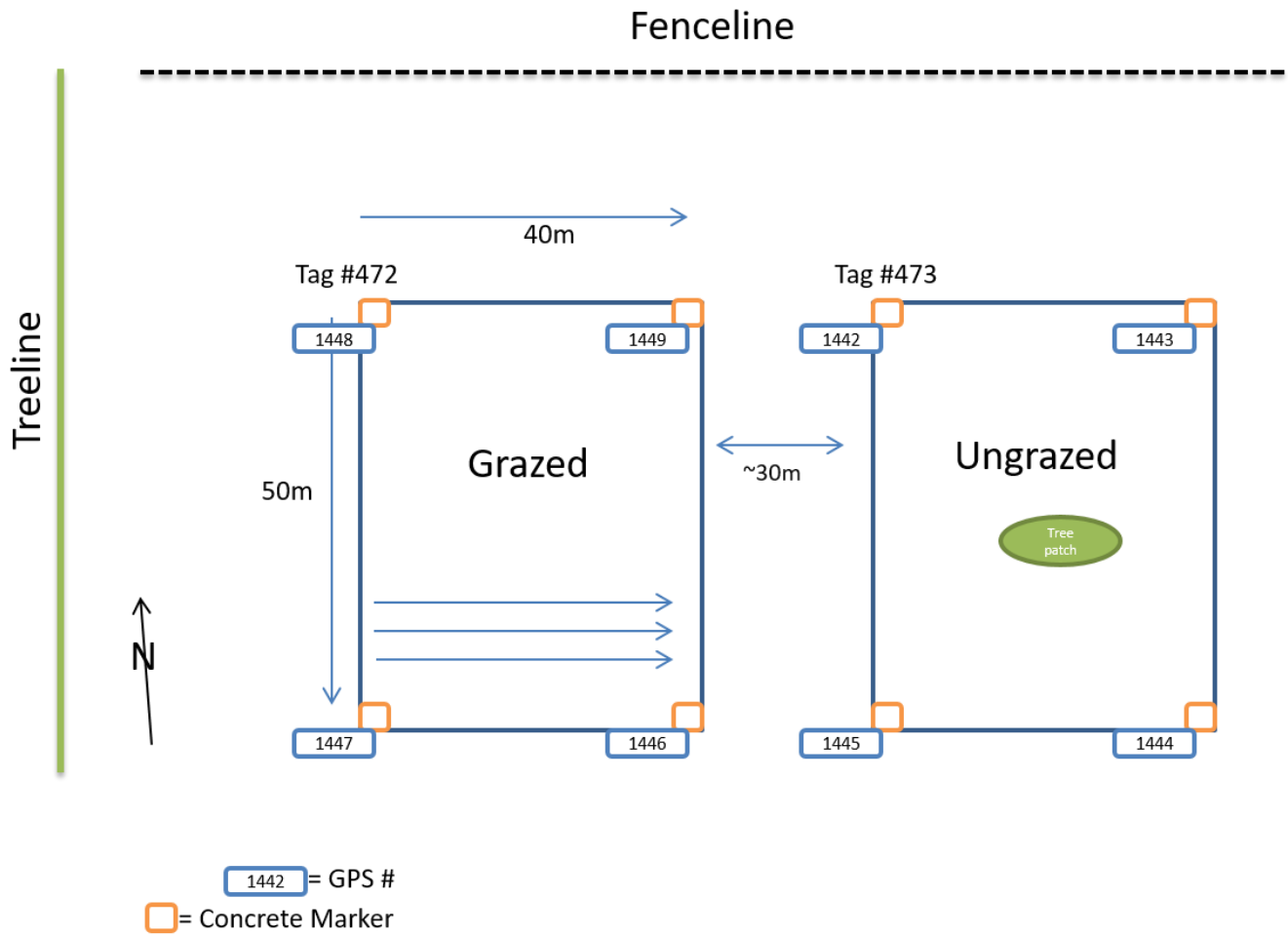

Figure 35. Schematic of plots at Sublimity Prairie. No Bradshaw's lomatium is present at this site. Plots are 40m x 50m with the longer axis running roughly north/south.

Figure 36. Aerial photo of plots at Sublimity Prairie. North is to the top of the page. Photo from Google Earth, taken July 2016.

Bradshaw's lomatium monitoring methodology

In 2018, IAE counted the total number of individuals within the grazed and ungrazed study plots at both CSW and Cutler Lane. The third study site, Sublimity Prairie, does not have Bradshaw's lomatium present, and was therefore not monitored for this species in either year.

During each year of monitoring, individual Bradshaw's lomatium plants were counted and classified into stage classes depending on the number of leaves, and reproductive stems. Only plants rooted within the plot boundaries were counted and assigned to a specific life-history category, as follows:

S	seedling
V1/2	vegetative with 1 or 2 leaves
V3	vegetative with 3 or more leaves
R1	reproductive with 1 umbel
R2	reproductive with 2 umbels
R3	reproductive with 3 or more umbels

Life-history categories were originally developed for Bradshaw's lomatium monitoring in the Willamette Valley (Kaye et al. 2001). Reproductive plants were segregated by umbel number because studies of Bradshaw's lomatium have shown that one-umbel plants rarely produce seed, while two-umbel plants produce seed on the second umbel, and three umbel plants may produce many seeds (Kaye 1992, Kaye and Kirkland 1994).

In 2016, IAE censused the population of Bradshaw's lomatium at Cutler Lane, keeping track of those individuals located within each of the study plots. Due to the timing of site access at CSW, IAE was unable to monitor Bradshaw's lomatium at this site in 2016; instead data from the 2012 surveys were utilized for a baseline. Data collected in 2012 followed protocols described in Silvernail et al. (2014). At this site due to the size of the population, a subsample of 26 transects were monitored and the population size estimated based on these sub-samples. For details on the 2012 methodology see Silvernail et al. (2014). The location of the transects utilized in 2012, extend beyond the edges of the grazing plots established in 2016, and thus direct comparisons of the number of plants cannot be made from 2016 to 2018, however comparisons can be made to differences in the population structure between the two plots and from 2012 to 2018.

Plant community monitoring results

PRE-GRAZING TREATMENT RESULTS

At CSW and Cutler Lane, the plant community was dominated by non-native graminoids with an average cover of 98.2% and 84.3% respectively in the treatment plots in 2016 (Figure 37). The dominant introduced species at CSW was meadow foxtail (*Alopecurus pratensis*), while at Cutler Lane, introduced species included reed canarygrass (*Phalaris arundinacea*), meadow foxtail and the lower statured water foxtail (*Alopecurus geniculatus*). Native graminoids were present in much lower amounts, with only 5.5% cover at CSW and 7.4% at Cutler Lane. Compared to the other two study sites, Sublimity Prairie had lower cover of introduced graminoids (39.5%), with bentgrass (*Agrostis* sp.) dominant. Native graminoids at Sublimity Prairie were higher than at other sites, with spikerush (*Eleocharis* sp.) and California oatgrass (*Danthonia californica*) the dominant species. Cover of annual grasses (both introduced and native) was low at all sites (0-4%); Cutler Lane had the highest cover of native annual grasses with 3%, and Sublimity Prairie had the highest cover of introduced annual grasses (4%).

In 2016, native forb cover ranged from 2.2%-16.8% at the three sites, with lowest cover at CSW and highest at Cutler Lane. Introduced forb cover ranged from 15.4%-35.8%, with Cutler Lane having the lowest cover of introduced forbs and Sublimity Prairie having the highest cover. Shrub cover ranged from 0.7-6.7%, with the highest shrub cover (predominantly of *Rosa* sp.) found at Cutler Lane (Figure 37).

At CSW and Cutler Lane, bare ground was the most common ground cover class (60.2% and 65.7% respectively) followed by litter. At Sublimity Prairie, litter was higher than bare ground (50.9% and 29.6% respectively) (Figure 38). Moss cover ranged from 7.4%-18.7%, with rock cover minimal at all sites (0%-3.4%).

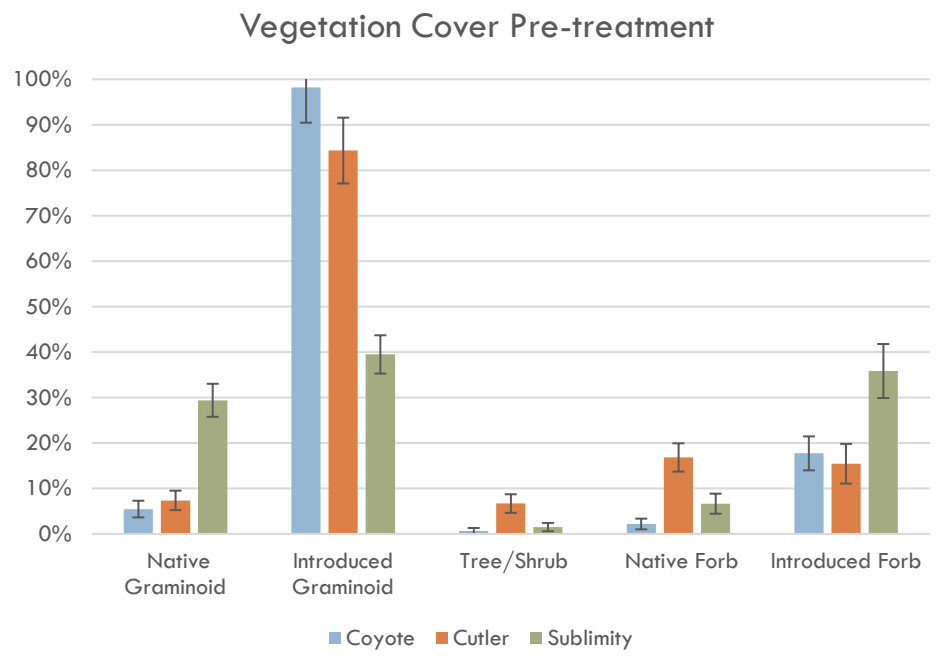

Figure 37. Percent cover of plant management groups in 2016.

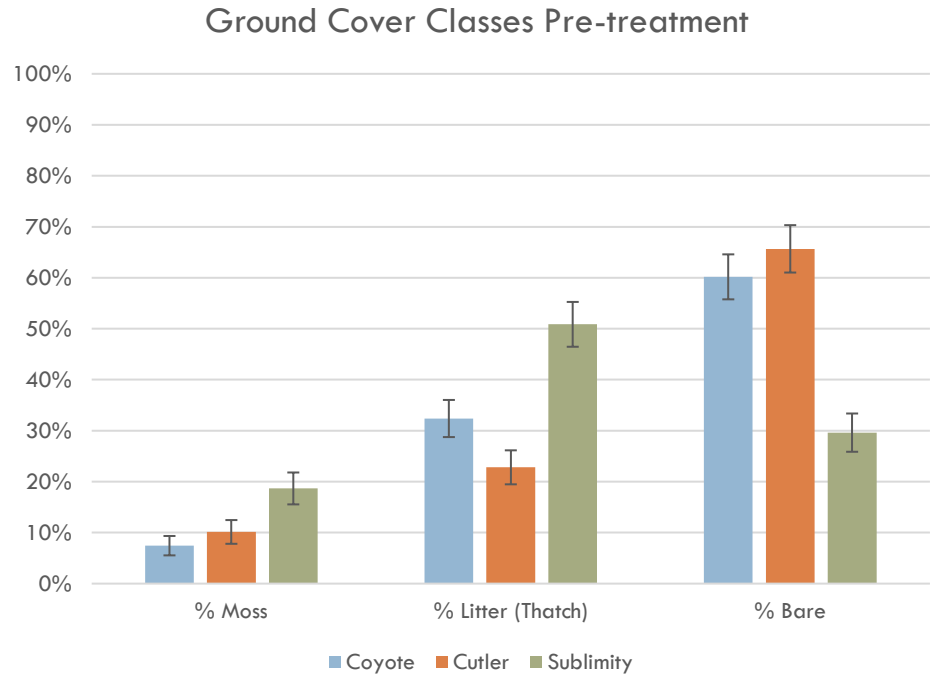

Figure 38. Ground cover classes pre-treatment in 2016.

POST-GRAZING TREATMENT RESULTS

Coyote Spencer Wetlands

This meadow is dominated by perennial invasive grasses, and is lined with *Fraxinus latifolia* and *Quercus garryana*. The majority of the Bradshaw's lomatium population is found along the treeline on the eastern edge of the meadow (Figure 3). At CSW the cover of introduced forbs decreased in both the grazed and ungrazed plots (from 26% to 16.1% and 9.6 to 4.3% respectively) (Figure 39, Table 9). This decrease was mostly due to a decrease in the cover of the annual species *Geranium dissectum* and *Vicia tetrasperma* (from 14.5% to 7.9% and 9.3% to 4.5% respectively in grazed plots). There were no significant changes in the cover of any plant management group as a response to grazing treatments at this site. Bare ground decreased in both the treated and untreated areas from 2016 to 2018 with a concomitant increase in litter (Table 9). Bare ground in the ungrazed plots decreased from 76.5% to 2.3%, grazed plots showed a similar trend from 43.6% to 2.4%. While these changes in ground cover classes are significant from 2016 to 2018, they occurred independent of grazing treatment and are likely the result of other management actions at the site. Both plots were mowed in the fall of 2016, and it is likely that plant material from those mowing events contributed to observed increases in thatch cover from May 2016 to May 2018 (Figure 39, Table 9).

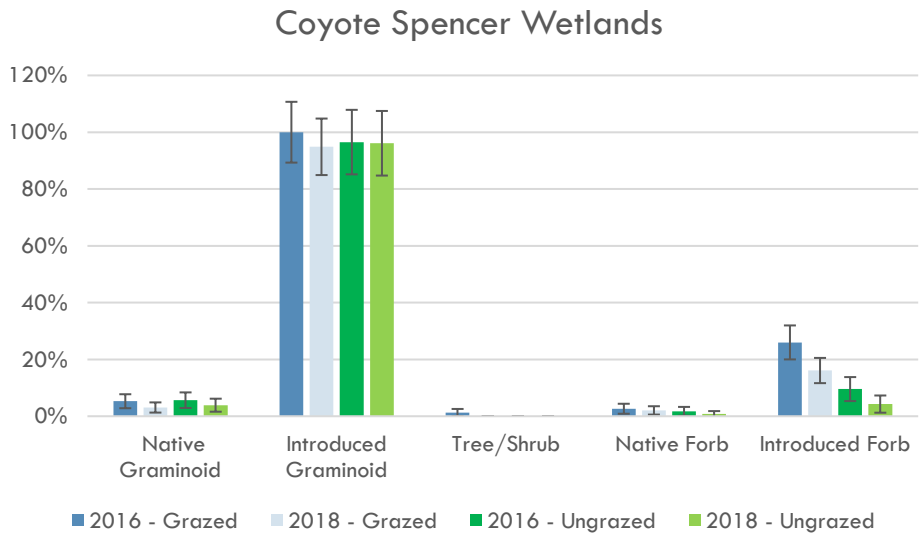

Figure 39. Percent cover by plant management groups at Coyote Spencer Wetlands. Error bars represent 95% confidence intervals.

Cutler Lane

At Cutler Lane, there was a significant decrease in the cover of introduced graminoids from 2016 to 2018 in the grazed portion of the population from 70.4% to 46.1% (Table 9, Figure 40). There was a decrease in the cover of native forbs from 2016 to 2018 in the ungrazed plot (the area of the population that was removed from the ambient grazing regime) from 14.7% to 5.8% (Table 9, Figure 40). There were not significant changes to other plant management groups at this site as a response to grazing. Similar to CSW there was a decrease in bare ground observed with a concomitant increase in litter cover (Table 9).

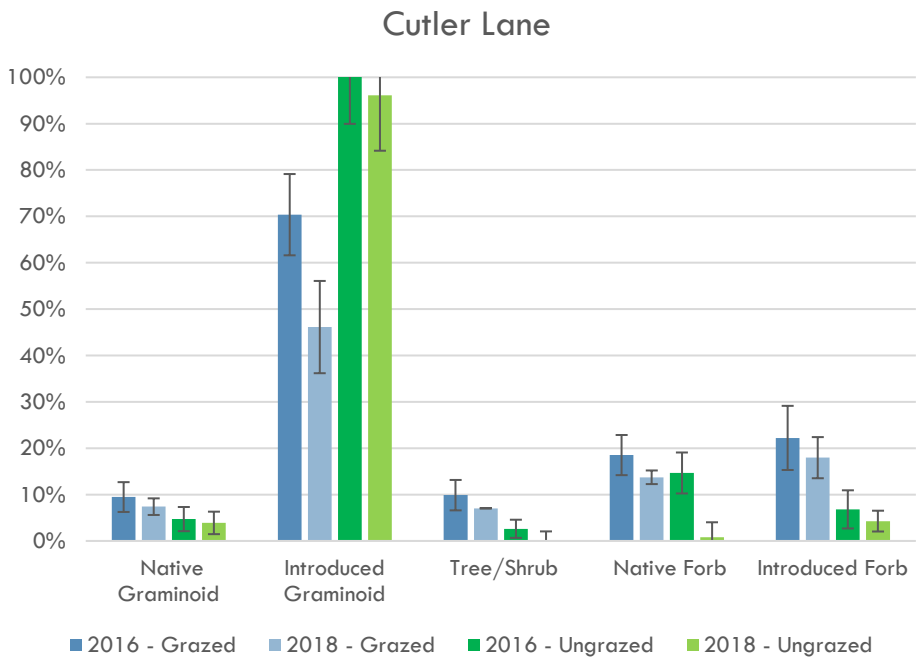

Figure 40. Percent cover at Cutler Lane by plant management groups from 2016 to 2018. Error bars represent 95% confidence intervals.

Sublimity Prairie

At Sublimity Prairie, there were not significant difference in percent cover of any plant management group between the grazed and ungrazed plots (Figure 41). There were not significant changes in the cover of bare ground or thatch at the site, but there were decreases in moss cover in the grazed plot from 23.7% to 5% (Table 9).

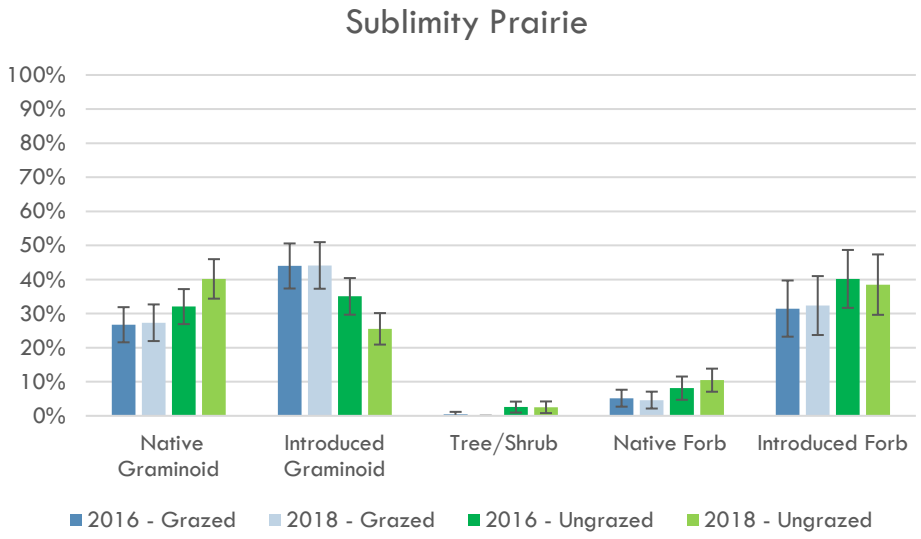

Figure 41. Percent cover at Sublimity Prairie by plant management group from 2016 to 2018. Error bars represent 95% confidence intervals.

Table 9. Mean cover of plant management groups and ground cover classes in May 2016 and 2018. Total plant cover can be more than 100% due to overlap of species. Values in () represent 95% confidence intervals.

	Native Graminoid	Introduced Graminoid	Tree/Shrub	Native Forb	Introduced Forb	% Moss	% Litter (Thatch)	% Bare Ground
COYOTE SPENCER WETLANDS								
Pre-treatment	5.5(1.8)	98.2(7.8)	0.7(0.6)	2.2(1.2)	17.7(3.7)	7.4(1.9)	32.4(3.6)	60.2(4.4)
GRAZED								
2016	5.3(2.5)	100.0(10.7)	1.3(1.2)	2.6(1.8)	26.0(6.0)	10.1(3.3)	46.3(6.0)	43.6(5.9)
2018	3.1(1.8)	94.9(9.9)	0.0(0.0)	2.1(1.5)	16.1(4.4)	4.5(2.3)	92.5(3.6)	2.4(1.7)
UNGRAZED								
2016	5.7(2.7)	96.5(11.4)	0.0(0.0)	1.7(1.6)	9.6(4.2)	4.8(2.1)	18.7(4.0)	76.5(6.4)
2018	3.9(2.3)	96.1(11.4)	0.0(0.0)	0.8(1.0)	4.3(3.0)	2.3(1.8)	95.3(3.1)	2.3(1.8)
CUTLER LANE								
Pre-treatment	7.4(2.1)	84.3(7.2)	6.7(2.0)	16.8(3.1)	15.4(4.4)	10.1(2.3)	22.8(3.3)	65.7(4.6)
GRAZED								
2016	9.5(3.2)	70.4(8.8)	9.9(3.3)	18.5(4.3)	22.2(6.9)	11.5(3.3)	18.9(4.1)	67.9(6.2)
2018	7.4(3.0)	46.1(7.6)	7.0(3.0)	13.7(4.0)	18.0(5.7)	9.2(3.0)	53.9(5.8)	37.0(5.3)
UNGRAZED								
2016	4.7(2.6)	102.1(12.1)	2.6(2.0)	14.7(4.4)	6.8(4.1)	8.4(3.2)	27.7(5.4)	62.8(7.0)
2018	3.1(2.4)	76.2(11.9)	2.2(2.1)	5.8(3.3)	1.3(2.2)	14.3(3.8)	39.5(5.7)	45.7(6.0)
SUBLIMITY PRAIRIE								
Pre-treatment	29.4(3.6)	39.5(4.2)	1.5(0.9)	6.7(2.2)	35.8(5.9)	18.7(3.1)	50.9(4.4)	29.6(3.8)
GRAZED								
2016	26.7(5.2)	44.0(6.6)	0.4(0.7)	5.2(2.5)	31.5(8.2)	23.7(5.0)	52.2(6.3)	24.1(5.0)
2018	27.3(5.4)	44.1(6.8)	0.0(0.0)	4.6(2.5)	32.4(8.6)	3.4(2.3)	63.4(6.2)	29.4(5.7)
UNGRAZED								
2016	32.1(5.1)	35.0(5.4)	2.6(1.6)	8.1(3.4)	40.2(8.5)	13.7(3.8)	49.6(6.1)	35.0(5.5)
2018	40.2(5.8)	25.5(4.6)	2.5(1.7)	10.5(3.4)	38.5(8.9)	18.0(4.5)	43.9(6.1)	35.6(5.8)

Bradshaw's lomatium monitoring results

COYOTE SPENCER WETLANDS: At CSW in 2012, a sub-sample of the area populated with Bradshaw's lomatium utilized for this study counted 935 plants with a population structure of 74% vegetative and 26% reproductive (Table 10, Figure 42). The estimated population size for the patch included in this study was 2,969 ±603 (Silvernail et al. 2014). In 2018, 959 plants were counted in the ungrazed plot, and 269 in the grazed portion of the population. Because only portions of this population are included in the experimental plots, the number of plants observed in 2012 and 2018 are not directly comparable, though population structure between the two years can be evaluated. In 2012, 74% of plants were vegetative (26% reproductive). In 2018 in the ungrazed portion of the population, 97% of the plants were vegetative, while in the grazed portion 84% were vegetative (Table 10, Figure 43). In 2018, there was a higher percentage of large reproductive (R2 and R3) plants in the grazed plots than in the ungrazed portions of the habitat in 2018 (9% vs 4% respectively); in 2012 9% of observed plants fell into the R2 and R3 categories (Table 10).

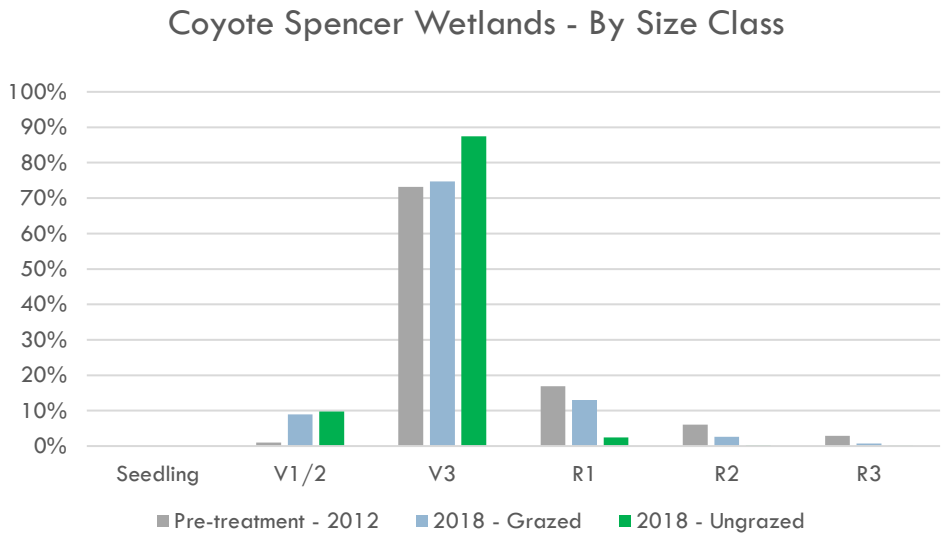

Figure 42. Percent of individuals in each size class at Coyote Spencer Wetlands pre-treatment (2012), and in 2018. Pre-treatment data was collected in 2012 as part of the range-wide inventory, and was not collected separately for the grazed and ungrazed plots at this site.

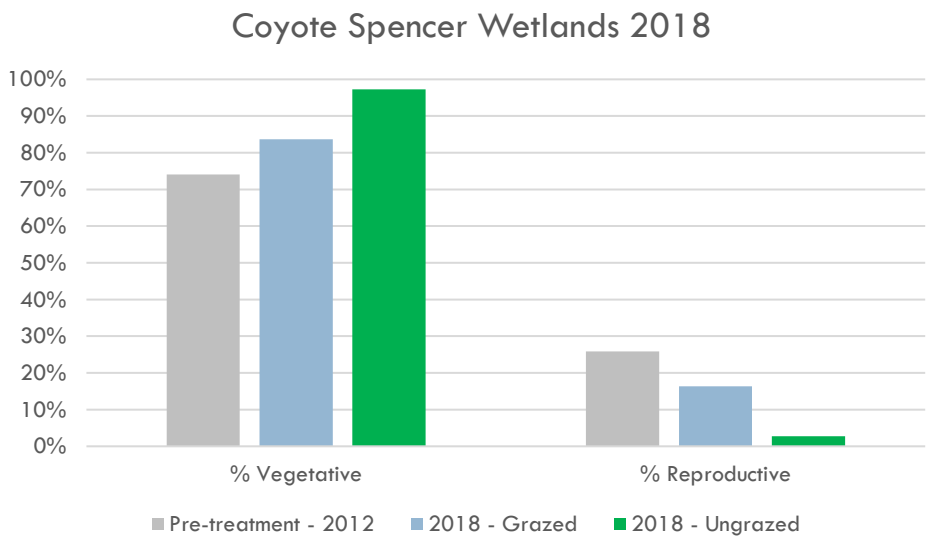

Figure 43. Percent of vegetative or reproductive individuals at Coyote Spencer Wetlands pre-treatment (2012) and in 2018. Pre-treatment data was collected in 2012 as part of the range-wide inventory, and was not collected separately for the grazed and ungrazed plots at this site.

CUTLER LANE: In 2016, 465 Bradshaw's lomatium individuals were counted in the plot that was scheduled to be grazed, and 255 in the area that was to be excluded from the ambient grazing regime at Cutler Lane. In 2018, the number of Bradshaw's lomatium observed in the grazed plot increased to 1,129 (Figure 44); however, no Bradshaw's lomatium were present in the ungrazed portion of the population (Table 10). Prior to treatments in 2016, seedlings were present in both treatment areas; grazed (6% of observed plants) and ungrazed (8% of all plants observed), and the population structure in both areas at Cutler Lane was similar with most plants (45%) falling in the V3 category (plants with 3 or more leaves, Figures 44 and 45, Table 10). In the ungrazed portion in 2018, no plants were present, and thus no seedlings were observed. In 2018, 49% of plants observed feel into the V1/2 size class, and 18% were seedlings. While there were shifts in the percentage of plants in different size classes in the grazed portion from 2016 to 2018, the relative proportion of vegetative to reproductive plants remained stable with 72% vegetative (28% reproductive) in 2016, and 76% vegetative (24% reproductive) in 2018 (Figure 45).

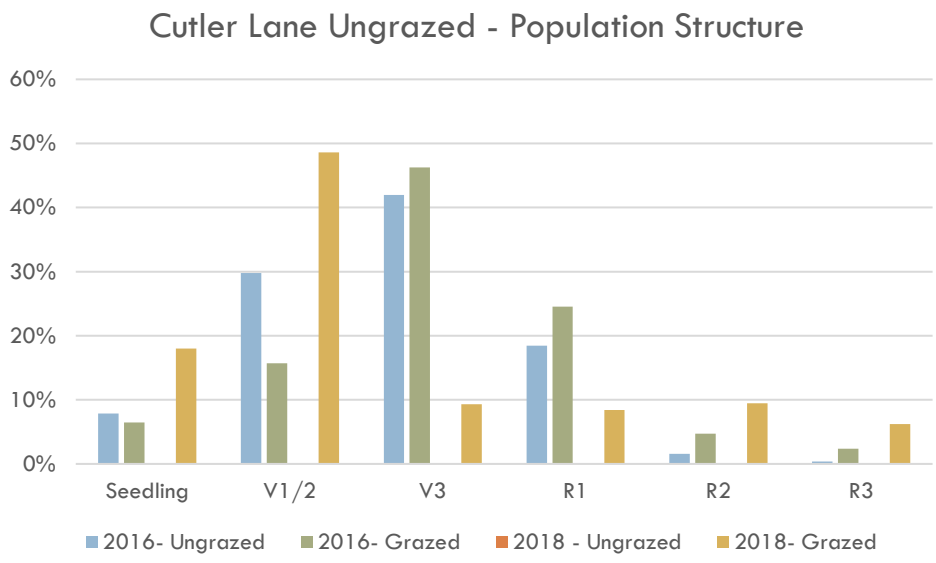

Figure 44. Population structure of Bradshaw's lomatium at Cutler Lane pre-treatment and in 2018. No plants were observed in the ungrazed portion in 2018.

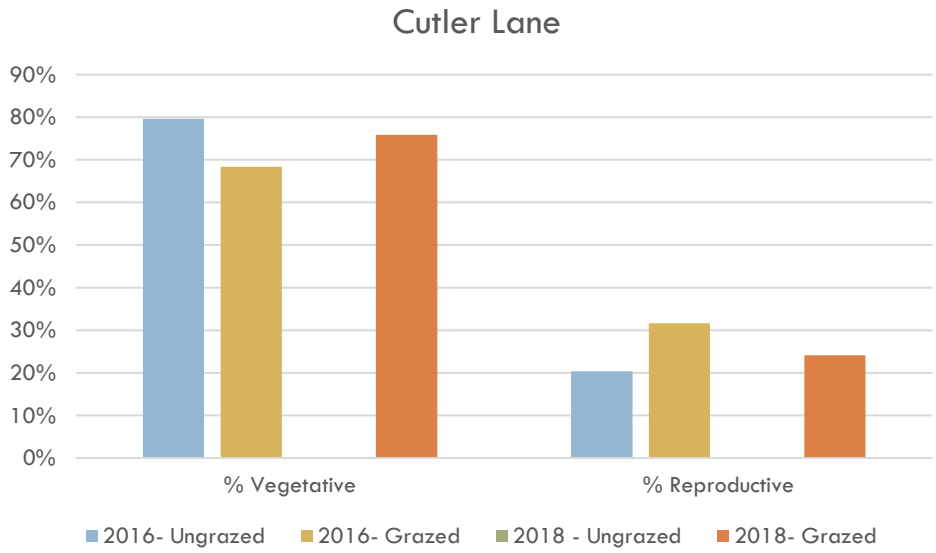

Figure 45 Percent reproductive and vegetative of Bradshaw's lomatium at Cutler Lane. No Bradshaw's lomatium were present in 2018 in the ugnrazed portion.

Table 10. Number (and percent of population) of Bradshaw's lomatium in grazed and ungrazed plots at Coyote Spencer Wetlands and Cutler Lane.

Site	Treatment	Year	Total	Seedling	V1/2	V3	R1	R2	R3	Total Vegetative	Total Reproductive
Coyote-Spencer	Pre-treat	2012	935	0 (0%)	9 (1%)	684 (73%)	158 (17%)	57 (6%)	27 (3%)	693 (74%)	242 (26%)
	Grazed	2018	269	0 (0%)	24 (1%)	201 (73%)	35 (17%)	7 (6%)	2 (3%)	225 (74%)	44 (26%)
	Ungrazed	2018	959	0 (0%)	94 (9%)	839 (75%)	23 (13%)	2 (3%)	1 (1%)	933 (84%)	26 (16%)
Cutler Lane	Pre-treat	2016	720	50 (7%)	149 (21%)	322 (45%)	161 (22%)	26 (4%)	12 (2%)	521 (72%)	199 (28%)
	Grazed	2016	465	30 (6%)	73 (16%)	215 (46%)	114 (25%)	22 (5%)	11 (2%)	318 (68%)	147 (32%)
		2018	1129	203 (18%)	549 (49%)	105 (9%)	95 (8%)	107 (9%)	70 (6%)	857 (76%)	272 (24%)
	Ungrazed	2016	255	20 (8%)	76 (30%)	107 (42%)	47 (18%)	4 (2%)	1 (0%)	203 (80%)	52 (20%)
		2018	0	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)

4. PROJECT CHANGES

The original proposals (#213-3020-9793 Restoration and 213-3020-9994 Effectiveness Monitoring) were funded by OWEB in 2012 for work on seven sites enrolled as NRCS WRP sites. In 2013, the project was amended when two sites, E-4 Ranch WRP and Mill Creek WRP, were dropped and Cutler Lane (no easement) and Kirkwood WRP were added to the project. In 2014 the NRCS withdrew permission to use grazing as a restoration tool on WRP sites. This required IAE to locate new sites to complete the project. To find new sites and complete the project, a project schedule extension request was granted to IAE in 2014 that extended the Restoration grant end date from June 30, 2015 to June 30, 2018 and the Effectiveness Monitoring grant end date from June 30, 2017 to June 30, 2020. The seven WRP sites originally proposed for this study were dropped. Cutler Lane was kept as a project site and two new sites, CSW and Sublimity Prairie, were added (Figure 2). The project budgets were adjusted to reflect the smaller scope of the project. The project change requests were accepted and the Restoration and Effectiveness Monitoring projects were reinstated in November 2015. Work on the three sites began in 2016 after the OWEB landowner Cooperative Agreement forms were signed and processed.

5. PUBLIC AWARENESS

5.1. Volunteer Planting

As a part of this project, IAE and McKenzie River Trust hosted volunteers to help plant native wet prairie plants at Cutler Lane and CSW. At Cutler Lane, 28 volunteers contributed 109.5 hours to plant over 9,500 bulbs, plugs and bare root plants. At CSW, 19 volunteers contributed 140 hours to plant 7,600 bulbs, plugs and bare root plants. At each of these events, IAE staff provided instruction on correct planting technique to improve plant survivorship. At the beginning of each planting day IAE staff provided information on the project including the grazing, why restoration of wet prairie is important and how volunteer efforts will benefit Bradshaw's lomatium habitat at both sites.

6. LESSONS LEARNED

Effects of short-term, high-intensity grazing at CSW and Sublimity Prairie

At CSW, a site dominated by the introduced, perennial *Alopecurus pratensis* (meadow foxtail), the population of Bradshaw's lomatium can only be found in portions of the site where this non-native species is not dominant. In the ungrazed portion of the population there was a decline in the number of reproductive individuals, and a shift towards vegetative plants (from 26% reproductive in 2012 to only 3% reproductive in 2018). The grazed portions of the population of Bradshaw's lomatium retained a population structure similar to that observed prior to grazing (26% and 16% reproductive in 2012 and 2018 respectively). At Sublimity Prairie, there were not significant differences in the plant management groups, and lomatium is not present at the site.

Changes in ground cover classes were observed in treated and untreated areas at Sublimity Prairie and CSW. At Sublimity Prairie, the cover of moss decreased from 24% to 3% in the grazed plot, while in the

ungrazed plot there were no significant changes in ground cover classes from 2016 to 2018. At CSW and Cutler Lane, both grazed and ungrazed plots showed a decrease in the cover of bare ground, and an increase in litter (thatch).

Long-term grazing at Cutler Lane

When the ongoing grazing regime was stopped at Cutler Lane for just two growing seasons, the number of Bradshaw's lomatium decreased from hundreds to zero in the ungrazed exclosure. This alarming decrease in the number of plants in this patch at Cutler Lane indicates that well-timed and ongoing grazing may play an important role in decreasing competition with non-native species, particularly invasive perennial grasses, at the site. At this site, when grazing ceased, the stature of reed canarygrass, and other invasive perennial pasture grasses increased so much that many stalks were above the heads of the field crew (Figure 19). The speed at which the Bradshaw's lomatium individuals disappeared from the ungrazed plot (over a two-year period) also highlights the importance of ongoing management actions to maintain populations of this imperiled plant.

At Cutler Lane in addition to the decrease in number of plants in the grazed plots, the dominant non-native perennial grass community shifted in the ungrazed plot from the lower-statured water foxtail to the taller-stature species, meadow foxtail and reed canarygrass.

While the grazing implemented in plots at CSW and Sublimity Prairie included grazing over a short (<3 day) period in each year, the grazing regime has been quite different at Cutler Lane, where the entire site was grazed annually from June through November since at least 2010, and prior to that had received grazing by both sheep and cattle at varying intensities. This site, formerly known as Allen and Allen, is host to a variety of native and rare prairie species including Willamette daisy (*Erigeron decumbens* var. *decumbens*), Nelson's checkermallow (*Sidalcea nelsoniana*) and thin-leaved peavine (*Lathyrus holochlorus*). A return to previous grazing practices at the site is strongly recommended so that introduced perennial grasses do not continue their spread into other areas of the site.

Invasive species and woody plant control

The primary threats to Bradshaw's lomatium and wet prairie habitats at the three project sites is non-native grasses and encroachment of shrubs and trees. Both require multiple herbicide applications to control. Thatch buildup and competition for resources likely limits the growth and reproduction of wet prairie species, including Bradshaw's lomatium. Grazing may temporarily reduce thatch and standing biomass to improve access to bare ground for seeding, but fall re-growth of non-native perennial grasses quickly occupied the areas cleared of vegetation. Repeated annual grazing at Cutler Lane (during and prior to this study) and presence of low stature grasses, such as water foxtail, appears to limit the dominance of other non-native grasses in the grazed meadow. Additionally, timing and intensity of common practice annual grazing at Cutler Lane has allowed native forbs and grasses to complete the life cycle to produce seed to maintain native plant diversity and contribute to the quality of the wet prairie habitat without negatively impacting the Bradshaw's lomatium. If long-term improvements to wet prairie habitats are to be made, non-native grasses need to be controlled and without the option to use herbicides, annual grazing is a viable option.

Attempts to control non-native perennial grasses, i.e. meadow foxtail at CSW and creeping velvet grass at Sublimity Prairie, by mowing followed by a fall glyphosate treatment were not effective at exposing bare ground or killing the grasses after one season. It is likely that multiple herbicide treatments combined with raking, intensive grazing, or burning at these sites are needed to adequately reduce competition and prepare the ground to receive native seed and other plant materials.

Mowing or brush cutting alone will not kill most resprouting shrubs or trees. Treating stumps after cutting limited resprouting of cut trees at CSW and Sublimity Prairie. However, the fact that the sheep did graze new shoots of resprouting shrubs and trees following brush cutting at Cutler Lane suggests that annual cutting followed by grazing could eventually reduce the abundance of shrubs and trees without the use of herbicides.

Grazing implementation

In both 2016 and 2017, there were multiple logistical challenges to introduce sheep grazing at CSW and Sublimity. Introducing sheep to the two project sites was costly. Factors that contributed to the cost include transportation of the sheep, temporary fencing around the grazing study plot, a corral to pen sheep in at night, and protection of the sheep by a dog, human or both from predators such as coyotes and cougars that were known to be present in the vicinity of the study sites. The quality of the forage, duration of the grazing period, access to the site and maneuverability around the site can affect cost or willingness of the shepherd to bring animals to a site. For example, if forage quality is high and abundant enough to contribute to weight gain or milk production, it is possible that the cost of bringing in animals to graze could decrease.

Bare ground measured in May of 2018 decreased or remained stable from values observed in 2016 in all experimental plots. This indicates that while bare ground may be created at the time of grazing (Figure 17), vegetation or thatch has occupied that space in the following growing period. Placement of water and shade will affect where sheep spend their time grazing, standing or resting and could be strategically placed in areas that would benefit from increased ground disturbance.

Before landowners would allow animals to be brought on to their property, multiple concerns needed to be addressed. Two of the primary landowner concerns were 1) the security and safety of the sheep and 2) preventing sheep from escaping to adjacent properties. Meetings that included landowners, IAE and the shepherd were necessary to reassure landowners that the sheep would be protected from predators while on their property. The safety of the sheep was the responsibility of the shepherd. Weed control in the grazed plot was limited to hand pulling to maintain the organic designation of these particular ewes and limit their exposure to herbicides (a consideration to be taken when selecting grazing contractors). Tansy ragwort was the primary target for hand weeding in the grazed plots at CSW and Sublimity Prairie, not only to limit herbicide use but to also to prevent sheep from grazing this toxic plant.

After two years, flash grazing alone appears to have little effect on reducing competition by non-native grasses at CSW and Sublimity Prairie. Annual flash grazing will likely need to be ongoing or combined with herbicide use to effectively reduce competition by non-native grasses at each site. If restoration efforts are to include grazing and herbicide use, careful planning with the shepherd to determine the timing of grazing and herbicide applications is necessary to limit exposure of animals to herbicides.

For this project, the need to graze the wet prairie later in the season (after Bradshaw's lomatium plants have flowered and set seed) meant that the grazing occurred when forage quality was low. This suggests that the forage benefits to milk producing ewes and marketable sheep is limited in these types of habitats if the presence of a listed species like Bradshaw's lomatium (or other high-value early season natives) requires grazing to occur later in the season.

7. RECOMMENDATIONS

Sublimity Prairie and CSW

At the two sites where grazing occurred for a short duration in the fall (CSW and Sublimity Prairie), there were not significant differences in vegetation cover from 2016 to 2018 between the grazed and ungrazed plots. It is possible that grazing for longer periods of time, with other grazing species, or following grazing with seeding or transplanting of native species could affect changes to the plant community in future restoration efforts. At CSW the shifts in population structure of Bradshaw's lomatium were not conclusive. Management at these sites should continue to target the removal of introduced perennial grasses and increasing native plant cover.

Cutler Lane

At this site, where the ongoing grazing regime includes annual grazing from June-November, the removal of grazing in a portion of the site, resulted in a significant decrease in the number of plants observed in the 'ungrazed' portion of the site. The absence in 2018 of an entire patch of Bradshaw's lomatium at Cutler Lane is cause for concern, and highlights the need for active management of populations of this imperiled plant. A return to the previous grazing regime is recommended for this portion of the site. Additional seeding or transplanting of native forbs, and control of tall-statured perennial grasses is recommended to reclaim the previously occupied habitat. At occupied sites where introduced pasture grasses have established, and grazing is a regular occurrence in the recent site history, grazing is recommended to continue to maintain the presence of this rare species.

8. REFERENCES

Drew, A. D. 2000. Effects of livestock grazing and small mammal populations on endangered Bradshaw's desert parsley (*Lomatium bradshawii*) at Oak Creek, Willamette Valley, Oregon. M.S. Thesis, Oregon State University, 65 pp.

Elzinga C. L., D. W. Salzer, J. W. Willoughby, J.P. Gibbs, 2009. Monitoring plant and animal Populations: a handbook for field biologists, Wiley & Sons 368pp.

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

Johnson, D. H. 1999. The insignificance of statistical significance testing. Journal of Wildlife Management, Vol. 63:763-772.

Kaye, T.N. 1992. Bradshaw's desert-parsley: population monitoring and pollination biology. Kalmiopsis 2:1-4.

Kaye, T.N. and M. Kirkland. 1994. Population biology of *Lomatium bradshawii*. II. Sexual expression, breeding system, and insect interactions. Unpub. Cooperative Challenge Cost Share report, Oregon Department of Agriculture, Plant Conservation Biology Program and Eugene District, BLM.

ORBIC (Oregon Biodiversity Information Center). 2016 Rare, threatened and endangered species of Oregon. Institute for Natural Resources, Portland State University, Portland, Oregon. 130 pp.

Ruggiero, N. and G. Kral. 2018. Prescribed cattle grazing as a tool for native prairie management: Lessons from the Tualatin River basin, Oregon. Journal of Soil and Water Conservation. 73(3): 74A-78A.

USFWS (U.S. Fish and Wildlife Service). 2010. Recovery Plan for the Prairie Species of Western Oregon and Southwestern Washington. U.S. Fish and Wildlife Service, Portland, Oregon. xi + 241 pp.

APPENDICES

Appendix A: Coyote Spencer Wetlands Photopoint Locations

(*Figure removed to protect of location of endangered species*)

Appendix B: Coyote Spencer Wetlands Photopoints

Coyote Spencer Grazed 2

July 19, 2016

September 16, 2016: Post Graze

June 28, 2017

July 18, 2017

August 9, 2017: Post Graze

October 12, 2017: Post Graze

June 4, 2018

Coyote Spencer No Graze 3

September 16, 2016

June 28, 2017

August 9, 2017

October 12, 2017

June 4, 2018

Coyote Spencer Field 4 – 3

August 22, 2017

October 12, 2017

November 13, 2017

June 4, 2018

Coyote Spencer Field 4 – 8A

August 22, 2017

October 12, 2017

November 13, 2017

June 4, 2018

Coyote Spencer Field 4 – 8B

			
August 22, 2017	**October 12, 2017**	**November 13, 2017**	**June 4, 2018**

Coyote Spencer Field 4 – 8C

			
August 22, 2017	**October 12, 2017**	**November 13, 2017**	**June 4, 2018**

Coyote Spencer Field 4 – 12

April 5, 2016

August 22, 2017

October 12, 2017

November 13, 2017

June 4, 2018

Appendix C: Cutler Lane Photopoint Locations

(*Figure removed to protect of location of endangered species*)

Appendix D: Cutler Lane Photopoints

Cutler Lane Graze 2A

		
September 21, 2016 before	**September 21, 2016 after**	**October 5, 2016**
		
June 28, 2017	**September 11, 2017**	**May 5, 2018**

Cutler Lane Graze 2B

		
September 21, 2016 before	**September 21, 2016 after**	**October 5, 2016**
		
June 28, 2017	**September 11, 2017**	**May 16, 2018**

Cutler Lane Grazed 4A

		
September 21, 2016 before	**September 21, 2016 after**	**June 28, 2017**
		
September 11, 2017	**October 16, 2017**	**May 16, 2018**

Cutler Lane Grazed 4B

		
September 21, 2016 before	**September 21, 2016 after**	**June 28, 2017**
		
September 11, 2017	**October 16, 2017**	**May 16, 2018**

Cutler Lane No Graze 2A

April 8, 2016

September 21, 2016

June 28, 2017

September 11, 2017

May 16, 2018

Cutler Lane No Graze 2B

		
April 8, 2016	**September 21, 2016**	**June 28, 2017**

	
September 11, 2017	**May 16, 2018**

Cutler Lane No Graze 4A

September 21, 2016

June 28, 2017

September 11, 2017

May 16, 2018

Cutler Lane No Graze 4B

September 21, 2016

June 28, 2017

September 11, 2017

May 16, 2018

Appendix E Sublimity Prairie Photopoint Locations

(*Figure removed to protect of location of endangered species*)

Appendix F: Sublimity Prairie Photopoints

Sublimity Prairie Grazed 1A

		
July 25, 2016 Pre Graze	**July 27, 2016 Post Graze**	**June 27, 2017**
		
July 28, 2017	**October 23, 2017**	**May 31, 2018**

Sublimity Prairie Grazed 1B

		
July 25, 2016 Pre Graze	**July 27, 2016 Post Graze**	**June 27, 2017**
		
July 28, 2017	**October 23, 2017**	**May 31, 2018**

Sublimity Prairie Grazed 3A

		
July 25, 2016 Pre Graze	**July 27, 2016 Post Graze**	**June 27, 2017**
		
July 28, 2017	**October 23, 2017**	**May 31, 2018**

Sublimity Prairie Grazed 3B

		
July 25, 2016 Pre Graze	**July 27, 2016 Post Graze**	**June 27, 2017**
		
July 28, 2017	**October 23, 2017**	**May 31, 2018**

Sublimity Prairie No Graze 1A

July 25, 2016

June 27, 2017

October 23, 2017

May 31, 2018

Sublimity Prairie No Graze 1B

July 25, 2016

June 27, 2017

October 23, 2017

May 31, 2018

Sublimity Prairie No Graze 3A

July 25, 2016

June 27, 2017

October 23, 2017

May 31, 2018

Sublimity Prairie No Graze 3B

July 25, 2016

June 27, 2017

October 23, 2017

May 31, 2018

Appendix G: Volunteer Advertisements

Coyote Spencer Wetlands Planting Event Advertisement and Volunteer Appreciation

ADVERTISEMENT TO PLANT WET PRAIRIE SPECIES AT COYOTE SPENCER WETLANDS

30 NOV - 1 DEC VOLUNTEER OPPORTUNITY WITH MCKENSIE RIVER TRUST NEAR EUGENE

EVENT DETAILS

WHAT: Join IAE and the McKenzie River Trust to plant wet prairie species at Coyote Spencer Wetlands near Eugene.

Coyote Spencer Wetlands is over 150 acres of mixed riparian forest and wet prairie at the confluence of Coyote and Spencer Creeks. This property has some best wet prairie habitat in the area and has recently been treated to remove encroaching shrubs and grasses. We need your help to plant 9000 plugs, bulbs and bare-root plant materials to increase diversity at the site. Your efforts will improve wet prairie habitat and habitat for rare species such as Bradshaw's lomatium, an endangered species, found on the property.

WHEN: 8:30 to 4:30 November 30th and December 1st

MEET: At IAE (563 SW Jefferson Ave.) at 8:30 am to carpool or caravan to Coyote Spencer Wetlands. Travel time is about 1 hour to the project site west of Eugene. If you live in Eugene or prefer to drive your own vehicle, you can meet us at Coyote Spencer Wetlands at 9:30.

WEAR: Boots and raingear to keep you dry.

BRING: Water, lunch, and snacks.

SPECIAL SKILLS: None needed!

PLEASE RSVP: Please be sure to RSVP to Andy Neill (andy@appliedeco.org) to make sure we bring enough tools for the planting event! You are welcome to drive with us or bring your own vehicle to the project site.

THANK YOU NOTE SENT BY MCKENZIE RIVER TRUST TO VOLUNTEERS WHO HELPED PLANT AT COYOTE SPENCE WETLANDS

Cutler Lane

ADVERTISEMENT FOR VOLUNTEERS TO PLANT WET PRAIRIE SPECIES AT CUTLER LANE.

9 - 10 NOV

TWO-DAY VOLUNTEER OPPORTUNITY: PLANT NATIVE PRAIRIE PLANTS NEAR CORVALLIS!

EVENT DETAILS

WHAT: Plant native plants to enhance wet prairie habitat near Corvallis!

WHEN: 8:30 to 4:30 November 9th and 10th (Timing is flexible if you bring your own car).

MEET: At IAE (563 SW Jefferson Ave.) at 8:30 am to carpool or caravan to the project site. Ride with us or bring your own car. Travel time is about 15 minutes to the project site 10 miles south of Corvallis.

WEAR: Boots and raingear to keep you dry.

BRING: Water, lunch, and snacks.

SPECIAL SKILLS: None needed!

PLEASE RSVP: Please be sure to RSVP to Andy Neill (andy@appliedeco.org) to make sure we bring enough tools for the planting event! You are welcome to drive with us or bring your own vehicle to the project site.

TIME

9 (Thursday) 8:30 Am - 10 (Friday) 4:30 Pm PST

LOCATION

Cutler Lane near Corvallis