Ecological and Economic Benefit-Cost Comparison of Grazed and Ungrazed Prairie Land for Critical Species Protection in Western Washington

2019 Annual Report

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Abstract
Most rangelands west of the Cascades in the Pacific Northwest occur on sites that historically supported native prairie. Over 90% of the prairies in this region have been converted to agriculture or lost to development, making conservation of this rare system a top conservation priority. At the same time, the human population in this region continues to grow, demanding more from regional food production systems. Therefore, agricultural producers are under great pressure from growing needs for food production and habitat conservation. Because of this, it is increasingly recognized that effective prairie conservation can only be achieved by partnering with private landowners to develop incentivized conservation strategies that maintain productive farms. Through a unique collaboration between agricultural producers, conservation scientists, economists, sociologists, regulators and agricultural researchers, we propose to evaluate if and how agricultural productivity can be maintained or enhanced in working landscapes while simultaneously accruing conservation value for rare native plants and animals. Through replicated on-farm experimental demonstrations, we will quantify the 'ecological lift' generated by conservation tools (altered grazing regimes, spring rest period, seeding native species). Additionally, we will evaluate the costs and benefits associated with conservation actions, to provide guidance on strategies and expenses for agricultural producers. Finally, we will survey producers to identify concerns, questions and needs (financial, technical, other) surrounding habitat conservation on their properties. The combined ecological, economic and social survey data will help guide government incentive programs. We expect this work to identify opportunities for agricultural producers to increase the conservation value of their properties, while maintaining or even enhancing their bottom line. Study findings and educational materials resulting from the demonstration trials will be communicated through peer-reviewed publications, presentations at academic conferences, a published grazing management guidebook, and a series of collaborative regional workshops for agricultural producers, researchers, extension agents, and land managers.

Project Objectives

1. Develop a regional network of three grazed prairie research sites to demonstrate and evaluate effects of conservation tools on prairie habitat. This objective will:
    a. Implement conservation tools for target species and habitats, with focus on management intensive grazing, exclusion during critical flowering periods and/or native seeding.
    b. Evaluate the impacts of conservation installations through a range of habitat and species-specific metrics over 3 years.
2. Utilize the regional network of grazed and ungrazed prairie sites, to quantify the financial costs and benefits associated with managing critical habitat and species over a 3-year period. This objective will:
    a. Provide practical financial information to farmers, the conservation community, and the county planners concerning the costs of meeting Habitat Conservation Plan (HCP) requirements on grazed and ungrazed prairies both on private and protected sites.

b. Develop enterprise budgets and a cost-benefit analysis to inform HCP acreage targets when protecting critical species on grazed land relative to conservation preserve land.

3. Engage private landowners by administering a social survey focused on landowner needs for increased involvement in land conservation programs (conservation easements, HCP, Safe Harbor Agreement). This objective will:
    a. Engage agricultural producers and regulatory entities in a productive discussion on incentives needed for habitat conservation on working lands.
    b. Provide feedback for regulatory programs on effective strategies to engage private landowners.
4. Present opportunities for technical assistance related to habitat management and discuss incentive opportunities with agricultural producers, regulatory agencies, and conservation land managers through several mechanisms:
    a. Workshop series, with field tours of the agricultural demonstration sites and native prairie preserve sites. Field tours will be sponsored by Washington State University (WSU), Center for Natural Lands Management (CNLM), Thurston County Conservation District, and Natural Resource Conservation Service (NRCS).
    b. Publications including a WSU-Extension technical bulletin providing management guidelines and financial data for conservation tools, as well as two published manuscripts in peer-reviewed journals.
    c. Presentation of findings at regional and national conferences.

Cooperators

Jensen, Kevin. Riverbend Ranch, Tenino, WA
Colvin, Fred. Colvin Ranch. Tenino, WA
Fisher, Bryan. Fisher Ranch. Rochester, WA
Chaney, Marty. NRCS. Olympia, WA
Chaput, Chris. Thurston County Community Planning, Olympia, WA
Watson, Phillip. University of Idaho Economics Dept., Moscow, ID
Painter, Kathleen. University of Idaho Extension, Bonner sFerry
Mallonee, Maynard. Mallonee Family Farm, Boistfort, WA
Sanders, Christina. WSU Division of Governmental Studies and Services, Pullman, WA.
Anderson, Brian. WSU Division of Governmental Studies and Services, Pullman, WA.
Bussan, Samantha. WSU Natural Sciences Graduate Program, Vancouver, WA.

Research

Hypotheses

1. Adoption of conservation grazing practices can improve the habitat value of grazed prairie sites
2. Conservation grazing practices may approach habitat value of ungrazed native upland prairie, as measured by native species richness, percent native groundcover, and butterfly behavior
3. Endangered or threatened species populations, such as Mazama pocket gopher, may be comparable in occupancy between grazed and ungrazed prairie sites

4. Grazing land productivity will not decrease as a result of adopting conservation grazing practices that improve habitat for endangered and threatened species
5. Integrating grazed working lands into conservation practices can result in a significant economic contribution to the regional economy, in comparison to removing working land from production for habitat and species protection
6. Specific strategies can be identified by farmers and ranchers to improve participation and trust in conservation programs and conservation partners

Materials and Methods

Three farm sites (Colvin Ranch, Fisher Ranch and Riverbend Farm) and three ungrazed prairie sites (Johnson Prairie, West Rocky Prairie, and Wolf Haven) were chosen for this study to represent a range of forage quality and practices and upland prairie habitat conditions. Within each farm site, six 1-acre paddocks were chosen for Conservation Grazing Practice (CGP) treatments (n=30), along with paired 1-acre Business as Usual (BAU) paddocks (n=30) (see site maps in Appendix 1). Assigned CGP treatments were developed through the NRCS Site Inventory Planning process (NRCS, 2017) and reflect site-specific conditions and desired natural resource outcomes for each ranch (Table 1).

Table 1. BAU and CGP Treatments for each farm site

Farm Site	BAU Treatment	CGP Treatment
Colvin Ranch	MiG with spring deferment	Native seeding
Fisher Ranch	Rotational grazing w/ spring deferment	Rotational grazing w/ spring deferrment and native seeding
Riverbend Farm	Continuous grazing	MiG w/ spring deferment; native seeding

Six areas within each of the selected native upland prairie (NUP) sites were also chosen as replicate plots to provide a comparison to the BAU and CGP treatments at the farm sites (Appendix A). We placed a 15 m x 15 m grid over maps of each of the 1-acre treatment plots at each site and randomly chose 5 subplots within each treatment plot. A range of community and species-specific variables were measured in these plots (Table 2).

Table 2. Treatments and response variables evaluated

Treatments (independent variables)	Business as Usual grazing (BAU), Conservation Grazing Practices (CGP), Native Ungrazed Prairie (NUP)
Site responses (response variables in BAU and CGP)	Forage height & biomass, uniformity of use, livestock concentration areas, soil compaction, erosion
Plant community (response variables)	Native and non-native species richness, percent cover of trees, shrubs, forbs, native grass, and forage grass; abundance of butterfly nectar and hostplants
Gophers (response variables)	gopher mounds/grid cell
Butterfly behavior (response variable)	Move lengths, turning angles and diffusion rates
Soil measures (site-level co-variates)	soil classification, soil nutrients

We constructed the necessary semi-permanent infrastructure for CGP treatments at Riverbend Farm (creating rotational paddocks) in fall 2018 and seeded a site-specific mix of native species into each of the CGP treatment paddocks at each site in October-November 2018 (Figure 1). Species were chosen according to several criteria: previous successful establishment in grazing systems, early season phenology, diversity of life histories (i.e., perennial, annual), low seed cost, and sufficient seed availability (see Appendix B for more information on species). Seeding rates were based on previously used rates in both upland prairie and in grazing systems and documented germination rates, when available. In spring 2019, we quantified seeded species establishment by counting individual seedlings within 4 systematically placed 1 m^2 quadrats within each 15 m x 15 m vegetation monitoring subplot.

Figure 1. The ten species selected for native seeding into farm sites. See Appendix B for full species descriptions.

Vegetation monitoring

To determine the native and non-native species richness in each site and each treatment, we recorded all plant species present in each of the five 15 m x 15 m subplots within each plot in each treatment (CGP, BAU, NUP) in spring 2019. Additionally, we recorded the percent cover of trees, woody shrubs, native forbs, forage species, native grasses, and abundance of butterfly resource species in each subplot (Figure 2, Table 2). To evaluate differences in plant community composition, we used nonparametric methods (Kruskal-Wallis, Non-metric Multidimensional Scaling) because our data were not normally distributed and transformations were inadequate to fit data to a normal distribution.

Figure 2. Conducting forage monitoring survey work at prairie and grazed ranch sites.

Gopher monitoring

Mazama pocket gophers are 100% fossorial, making measures of abundance extremely difficult and labor intensive. Instead of tracking abundance through live-trapping, we have chosen to track presence/absence sign (i.e., mounds; Figure 3) and use these data to determine occupancy estimates. Occupancy as a metric of population status that indicates the proportion of the landscape that is being utilized by the target species. This technique requires repeat visit surveys of fresh mounds (< 48 hrs. old) within the treatment areas so that seasonal and annual impacts to mound-building are accounted for. We visited plots three times in Fall 2018 and 2019 with a 3- to 5-day interval between visits. Each survey consisted of searching plots for two minutes or until fresh gopher mounds were located. Surveys will be repeated each fall throughout the project period to determine how occupancy is changing over time within each treatment.

Figure 3. Old gopher mound with native *Ranunculus occidentalis* growing out of it at Colvin Ranch.

Butterfly behavior

In high quality habitat, butterflies tend to have movement paths comprised of short, quick steps and high turning angles. This behavior results from concentrated individual search behavior in areas with high reward (high density of resources or oviposition/ reproductive sites) in contrast to highly mobile search behavior in areas with low reward (low density of resources or reproductive sites, often called “matrix”). This is also often called an “Area Restricted Search”. With measures of move rate (low or high mobility) and turning angles, we can calculate habitat-specific dispersal, or diffusion rates.

Figure 4. Initial butterfly evaluation at West Rocky Prairie

Funds from Western SARE do not include funding for this aspect of the study in Year 2 (2019). We obtained another grant from Conservation, Education, and Research Opportunities International (CREOi) for butterfly behavior observations (Figure 4). From April-September 2019, we quantified behavior at six sites, two in each of the three management categories. We observed two species: silvery blues (*Glaucopsyche lygdamus)* in the early season and ochre ringlets (*Coenonympha tullia eunomia*) in early and late season. We conducted our observations by releasing an individual and following it at a distance for up to 60 minutes. Each individual’s behavior was recorded and position marked with a pin flag every 15 seconds. From these observations we calculated the move length, turning angles, and diffusion rate in each habitat category. The data in 2019 will be used for the observational portion of the butterfly portion of this project. Butterfly host plant and nectar data were also collected. Data will be analyzed in 2020.

Soil nutrient assessment

Baseline soil nutrient status was evaluated in Fall 2018 from the three cooperating ranch sites and the three prairie sites. Where soil conditions allowed, fifteen ¾" soil cores from each replicate paddock/unit were obtained to a depth of 8 inches. In instances where rockiness prevented soil auger penetration, at least one exposed face soil sample from each quadrant of each replicate was collected to 8". The exposed face consisted of exposing a vertical soil profile to 8", which required an approximately 6" x 6" area excavation through gravelly conditions. Sub-samples from each replicate were combined, and a composite sample from each of the six replicates within each research site was sent to A&L Soil Testing Laboratories (Portland, OR) for analysis. Samples were refrigerated prior to shipping, then wrapped with gel packs in bubble wrap for transit. Samples were analyzed for nitrogen, phosphorous, potassium, calcium, magnesium, sulfur, iron, copper, zinc, manganese, boron, pH, cation exchange capacity, organic matter and estimated nitrogen release.

Forage biomass sampling

Total forage biomass production was estimated by sampling the two primary forage production flushes per season. The first was a spring growth period between approximately March and the beginning of June at which point dry conditions effectively precluded further growth and forage dormancy began. The second was a fall growth period between approximately mid-September when fall precipitation began, and the end of October when cool conditions limited further growth.

Timing and frequency of forage biomass and height estimations at prairie and ranch sites varied by site (Table 3). Rotationally grazed sites were sampled in April, June, and December to capture early season, spring, and fall forage production, respectively (Colvin, Fisher, and CGP treatment at Riverbend). Prairie sites were sampled in June only. The BAU treatment at Riverbend (continuous grazing) was sampled monthly from April through September to emulate continuous grazing of ruminant livestock.

Table 3. Timing of biomass and height measures at grazed and ungrazed prairie sites in 2019.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Fisher				x		x			x			x+
Colvin				x		x			x			x
River				x	x	x	x	x	x			x
John						x						
West						x						
Wolf						x						

Rotational grazing management employed at Fisher and Colvin ranches
Rotational and continuous grazing employed at Riverbend where CGP included not only seeding but also a grazing paddock system.

Total spring-summer biomass only was measured at ungrazed prairie sites (Johnson Point, West Rocky, and Wolf Haven)

At the ungrazed prairie sites, three of five 15 m x 15 m subplots within each replication were randomly selected along a rough transect through each of six replications. One biomass sample was collected from each of the three subplots using a randomly tossed 4.8 ft^2 cable ring (Figure 5). Aboveground plant material was clipped to ground level within each ring, creating a total of 3 sub-samples per replication. Sub-samples were dried at 55°C for five days at the WSU Puyallup Research and Extension Center. Dried weights were obtained to the nearest one-tenth gram, and averaged to provide six replicate values per site (18 total measures, n=6).

Sampling at grazed sites utilized two grazing exclusion cages (Figure 6) per treatment (one in CGP, one in BAU). Each of the two cages was paired, at each time of sampling, with a no-cage sample randomly collected using the same cable method described above, providing a protected and unprotected biomass estimation (Figures 7, 8). Cages at rotationally grazed sites were used to monitor any “unplanned” grazing that may have occurred prior to sampling, while cages in the continuously grazed treatment at Riverbend (BAU) allowed for spatial before-after biomass measures. Cages were moved after each sampling, and the difference between caged and no-cage measures approximated the biomass produced from the last time of sampling. In this way biomass production in a continuous system consisted of monthly measures additive to the initial April sampling.

Figure 5. Forage biomass sampling utilizing NRCS cable hoop method.

Figure 6. Installing a grazing exclusion cage at Riverbend Farm.

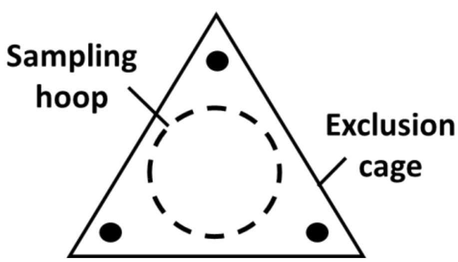

Figure 7. One biomass sample was collected per exclusion cage within each experimental unit, and one in an adjacent ‘no-cage’ position. The ring was well within the cage footprint to avoid peripheral grazing. Height measurements were taken at 3 locations (black circles) approximately 10 in. inside each corner of the exclusion cage.

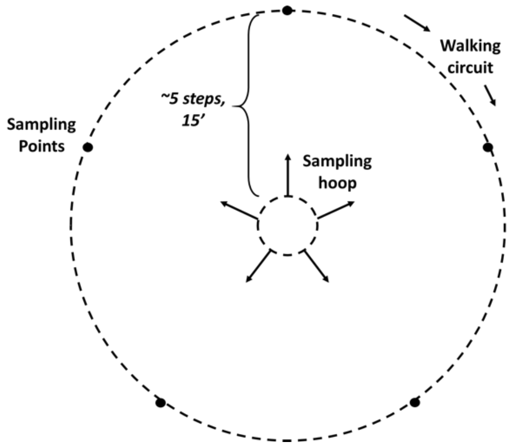

Figure 8. One 'no-cage' biomass paired with the cage measure was collected by randomly tossing the cable ring within each respective experimental unit. Height measurement were taken at 5 locations distributed at equidistant points along a circle around the randomly cast sampling hoop as illustrated.

Total biomass production at prairie sites and rotationally grazed sites was estimated using June-only measures. Non-significant grazing activity occurred as of the April sampling (data not reported), and biomass as measured in June was additive to what had already been produced by April (same forage, merely taller). Total biomass production at continuously grazed sites consisted of total biomass measured in April, followed by additive monthly samplings to estimate what was being grazed off by livestock. Fall biomass production data for 2019 were not yet analyzed at the time or reporting.

Forage height

At ungrazed prairie sites, three height samples were collected in each of three subplots used for biomass sampling. Starting from a reference point on the southwest corner (located by GPS) of each subplot, three height measures were collected at a series of 15-pace intervals in the directions north by northwest, then northeast, and then again north by north by northwest. Three height measures per sub-sample across three subplots across six replications were collected (36 total measures, n=6). Americorps members assisted with data collection for all vegetation and forage metrics (Figure 9).

Figure 9. Preparing Americorps volunteers for field work at Riverbend Farm.

Forage height estimations at grazed sites were collected as noted in Figures 7 and 8. At cage locations, a measure was taken within each corner of the exclusion cage, while at no-cage locations, five measures were collected along a circle paced around the randomly tossed no-cage biomass sampling ring.

Biomass Utilization
Documenting percent biomass utilization is reported here, and is important to monitoring efficiency of forage use. However, it is complicated by potentially incomparable sampling methods, and high variability across sites, between treatments, and within experimental units. Some challenges were as follows:

- Monitoring continuous grazing using the cage method relied upon calculating the difference between cage and no-cage biomass (a spatial approach: one protected sample here, a second unprotected sample there, taken during the same visit). Percent utilization can be estimated for each sampling period by dividing the biomass consumed (difference) by the total (caged). This measure averaged over every sampling period (in this case six mo) provided a season-long estimation of forage utilization.
- Monitoring rotationally grazed biomass relied upon calculating the difference between pre-grazed treatments (June sampling), and post-grazing (September sampling), representing a temporal approach: post-grazing samples (leftovers) substracted off pre-grazed samples (total available) to estimate forage consumed.
- While these are arguably the only available methods to compare percent forage utilization (spatial cage/no for continuous, and before/after for rotational) between these grazed systems, the methods are concerningly different, particularly in light of additional substantial differences in overall biomass available in these systems at each time of sampling. Continously grazed forage was between 0.25 and 3 in tall, and biomass in continuously grazed systems caged one month since the previous clipping was itself hardly taller. By comparison, rotationally grazed paddocks prior to grazing were 15 in and greater, while post-grazing paddocks in rotational systems remained 5 to 10 in in height with considerably variability from trampling and oxidation by September post-graze sampling.

Soil taxonomy work
Taxonomic soil descriptions were completed by the USDA Natural Resource Conservation Service Soil Survey staff operating out of Olympia, WA. One to three soil pits were excavated at each site; the number of pits depended on the presence or absence of mima mounds or low-lying topography. Both mound and intermound soil pits were dug on sites with mounds and pits were dug at other distinct landforms such as a low-lying area. Soil taxonomic work consisted of excavating soil with shovels to appropriate diagnostic horizons, which typically did not exceed 100 cm. Methods presented in the *NRCS Field Book for Describing and Sampling Soils* (version 3.0) were utilized to document site characteristics including parent material, landforms, land shape, and drainage, as well as diagnostic features (i.e., diagnostic horizons) and soil pit descriptions consisting of horizonation, color, texture, and structure (Table 2). Full soil taxonomic descriptions were included in a final report by NRCS staff.

Survey of Grazing Practices in Southwest Washington
We developed a survey to gather information on grazing practices in western Washington, potential barriers and incentives to implementing conservation practices for landowners, and feedback regarding regulatory programs and agency relationships. The survey contained questions related to land use and land use history, potential conservation barriers and

conservation incentives, relationships with agencies/organizations, and demographics. The questions were formatted as multiple choice or Likert Scale. There was also a section where we invited respondents to tell us any information they felt was not covered in the rest of the survey.

We vetted the survey through a meeting with a focus group comprised of producers participating in the grant (Fred Colvin, Kevin Jensen, and Maynard Mallonee) in fall 2018. The producers each took the survey in draft form and then provided feedback on terminology, clarity, length, flow, and question relevance. We obtained the certificate of exemption from further review from Washington State University's Internal Review Board in February 2019. We used a mixed method (Dillman 2007) to distribute the surveys online and in print for producers for whom we did not have email addresses. We built the emailed surveys through the survey software Qualtrics© and built the printed version in Microsoft Word. We partnered with participating organizations throughout western Washington, including WSU county extensions, farm bureaus, conservation districts, and others, to distribute the survey via anonymous Qualtrics link to their email databases. We were also able to obtain mailing addresses of some landowners through the Thurston and Lewis county extensions and mailed surveys to landowners for whom we did not have email addresses. Over 300 printed surveys were mailed.

Enterprise budgets

Enterprise Budget Development for Cattle Production

A meeting with producers was held for the purpose of conducting a Delphi Method survey of costs of cattle production in Thurston County. The DM is a formalized approach to assembling a group ofexperts and soliciting information in their area of expertise (Linstone and Turoff, 1975 and Weblar et al 1991), in this case, regarding the costs and earnings associated with various prairie grazing practices. Enterprise budgets were created that compare earning from traditional cow-calf production systems and grass-finished beef enterprises that market directly to consumers. These budgets will be finalized pending review by subject area specialists, and a draft 50-head Cow-Calf and Grass Finished Steers Enterprise Budget is included in this report.

Costs Estimates for Prairie Habitat Restoration Scenarios

A meeting with project personnel and stakeholders provided detailed scenarios for determining costs for three different prairie habitat restoration scenarios. These include Scotch Broom infested parcels, abandoned farmland, and abandoned rangeland. Specific annual operations for habitat restoration extend over multiple years. Relatively aggressive management is required to convert previously unmanaged land into prairie habitat with native species. Repeated burning, mowing, spraying and planting over many years would be required to restore these lands to their native status. These cost estimates are currently being developed and reviewed.

Results and discussion

Seeded Species Establishment

Out of the 10 species we seeded into CGP treatments, 4 successfully established: *Collinsia parviflora* (maiden blue-eyed Mary), *Plectritis congesta* (sea blush), *Ranunculus occidentalis* (western buttercup), and *Lupinus bicolor* (bicolor lupine). Presence of *Collinsia parviflora* and *Lupinus bicolor* in the BAU treatments was due to the fact they were already established at sites before seeding occurred (Table 4). Success of these particular species may be attributed to their annual growth strategy (with the exception of *Ranunculus occidentalis*, which is perennial) which entails high reproductive effort within a short life cycle. Alternatively, these species may be able to germinate and survive under a wide array of environmental conditions, as they tend to do well on many prairie restoration sites.

Table 4. Mean absolute abundance of native seeded species (± 1SD) across the different sites and the three treatments (n=30). Absolute abundance is quantified as the number of individuals per 1m2 monitoring plot.

Site	**Treatment**	*Collinsia parviflora*	*Plectritis congesta*	*Ranunculus occidentalis*	*Lupinus bicolor*
Colvin	BAU	0	0.03 ± 0.18	5.73 ± 10.49	0.23 ± 0.90
Colvin	CGP	0.63 ± 1.3	5.37 ± 11.03	12.13 ±29.82	0.23 ± 0.82
Fisher	BAU	2.63 ± 5.4	0	1.43 ± 4.92	0.1 ± 0.31
Fisher	CGP	11.43 ± 12.8	4.27 ± 3.48	4.73 ± 10.36	0.27 ± 0.52
Riverbend	BAU	0	0	0	0.37 ± 1.35
Riverbend	CGP	0	0.5 ± 1.32	0	0.04 ± 0.19
Johnson	NUP	0.8 ± 2.54	1 ± 3.89	0.47 ± 1.41	0.87 ± 1.25
West Rocky	NUP	0	0	0.1 ± 0.40	0.37 ± 1.3
Wolf Haven	NUP	0.72 ± 1.49	0.86 ± 2.67	1.07 ± 2.31	1.07 ± 2.76

Native Species Richness

Native species richness varied by site in 2018 and 2019, with native upland prairie sites hosting more native species than farm sites, with a notable development. Native richness significantly increased within CGP treatments over 2018-2019 ($p<0.001$) whereas there was no change within BAU ($p=0.56$) or within NUP ($p=0.47$) treatments over this same time frame (Figure 10).

Increased native species richness was observed at all ranch sites: Colvin and Fisher gained approximately three species on average while Riverbend gained one species (Figure 4a-b). The increase in richness was due to the seeding of native species, in particular *Plectritis congesta*, *Collinsia grandiflora*, and *Ranunculus occidentalis* (Table 4). Compared to native ungrazed prairies, native species richness at ranch sites was much lower (2-10 species on average at ranch sites compared to 15-21 species on average in NUPs) (Figure 11a-b).

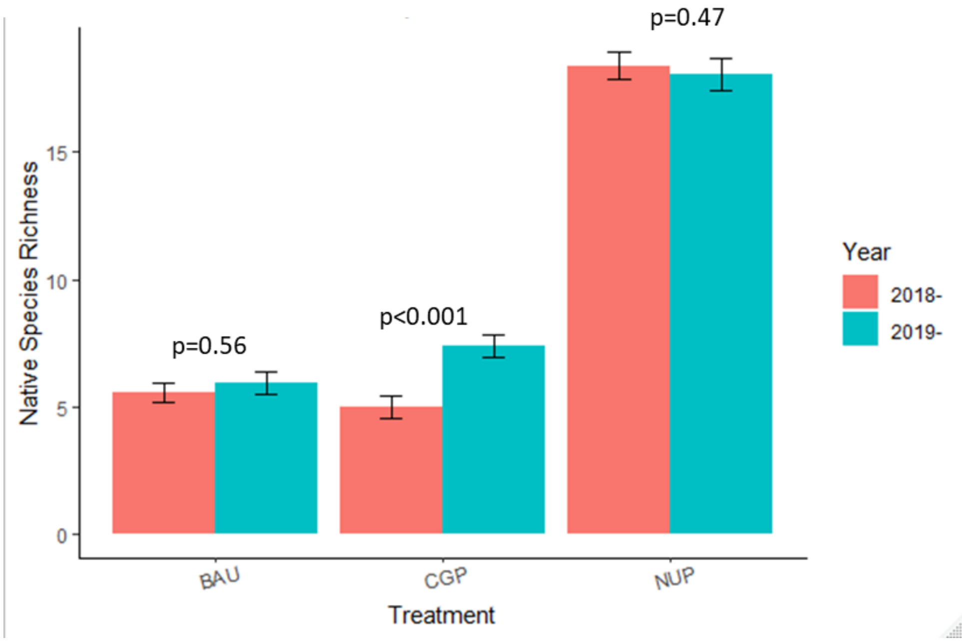

Figure 10. Native species richness across treatments (n=30) in 2018 versus 2019. P-values are from Kruskal-Wallis tests. Error bars represent ±1 SE.

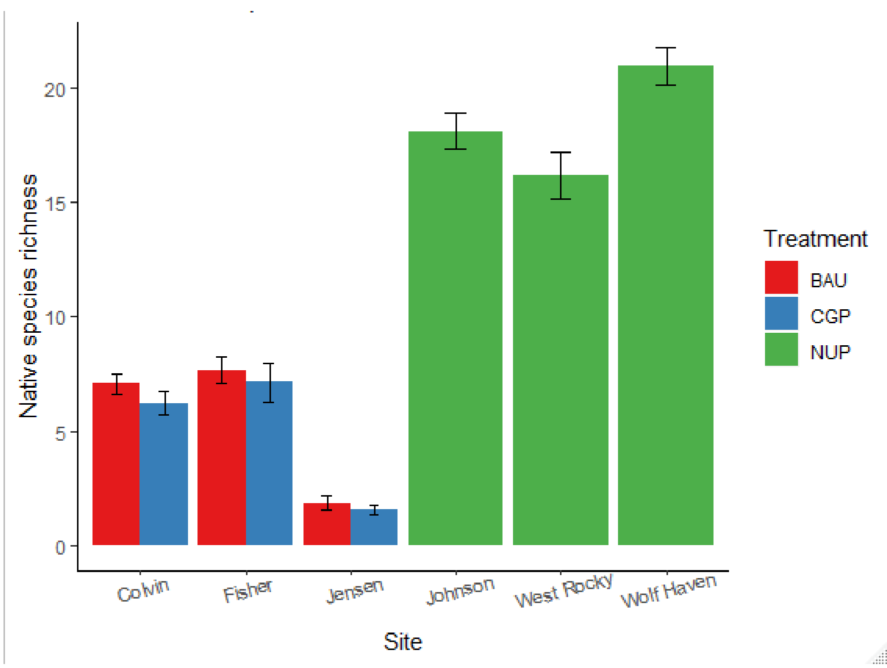

Figure 11a. Native species richness across study sites and treatments in 2018 (n=30). Error bars represent ±1 SE.

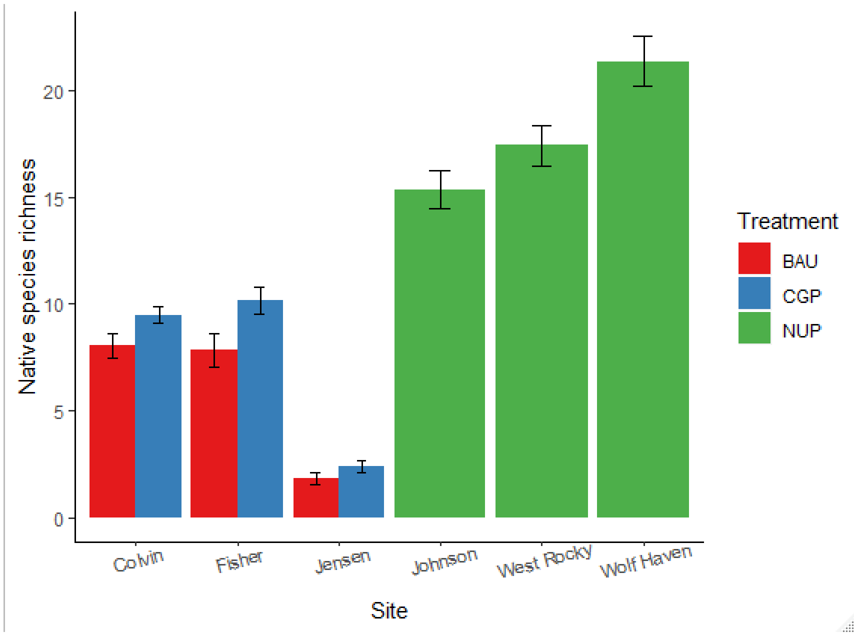

Figure 11b. Native species richness across study sites and treatments (n=30) in 2019. Error bars represent ±1 SE.

Non-native Species Richness

Non-native species richness showed minimal change from 2018 to 2019. Both BAU and CGP treatments showed a slight increase (~1 species on average for each treatment), but this was not statistically significant (BAU- p=0.25; CGP- p=0.12) (Figure 5). Native ungrazed prairies hosted approximately 14 non-native species on average in both 2018 and 2019 (Figure 12).

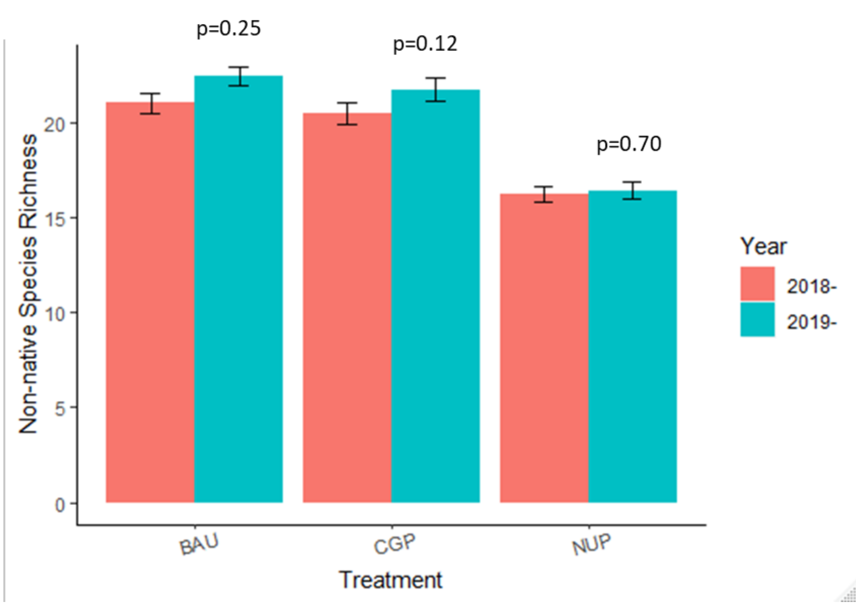

Figure 12. Non-native richness across treatments (n=30) in 2018 and 2019. P-values are from Kruskal-Wallis tests. Error bars represent ±1 SE.

Plant community composition over time

To visualize changes in plant community composition over time, we used non-metric multidimensional scaling ordination. This method clusters communities based on similarity so that assemblages that are more similar in species composition are closer together while those with disparate compositions are farther apart.

Overall, species composition across all plots became more similar from 2018 to 2019, as indicated by tightening of the plots across both Axis 1 and Axis 2 (Figures 13, 14). Subsequent similarity percentage analysis (SIMPER) showed that *Hypochaeris radicata*, *Plantago lanceolata*, and *Rumex acetosa* increased in frequency across monitoring plots between 2018 and 2019, leading to increased similarity in composition. The native ungrazed prairie sites all clustered together, reflecting similarity in composition across these sites. The ranch sites also clustered together, with Fisher Ranch and Colvin Ranch hosting several plots with similar plant community compositions. The BAU & CGP treatments within each ranch site are intermingled, suggesting they are not distinct from each other. Over time, we may expect CGP plots to become more similar to NUP as more native species become established.

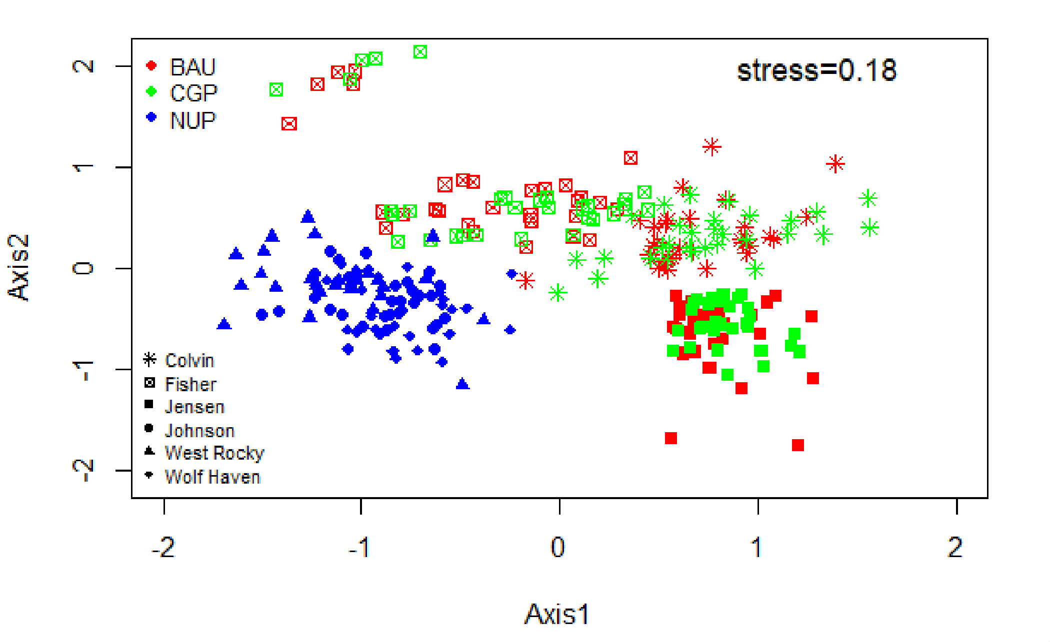

Figure 13. Non-metric multidimensional scaling (NMDS) ordination of plant communities in 2018. Each point represents the plant community in a single monitoring plot. Study sites are represented by different shapes while treatments are denoted with varying colors. The stress value indicates how well the data are represented by the ordination with stress = 0.18 indicating a fair representation.

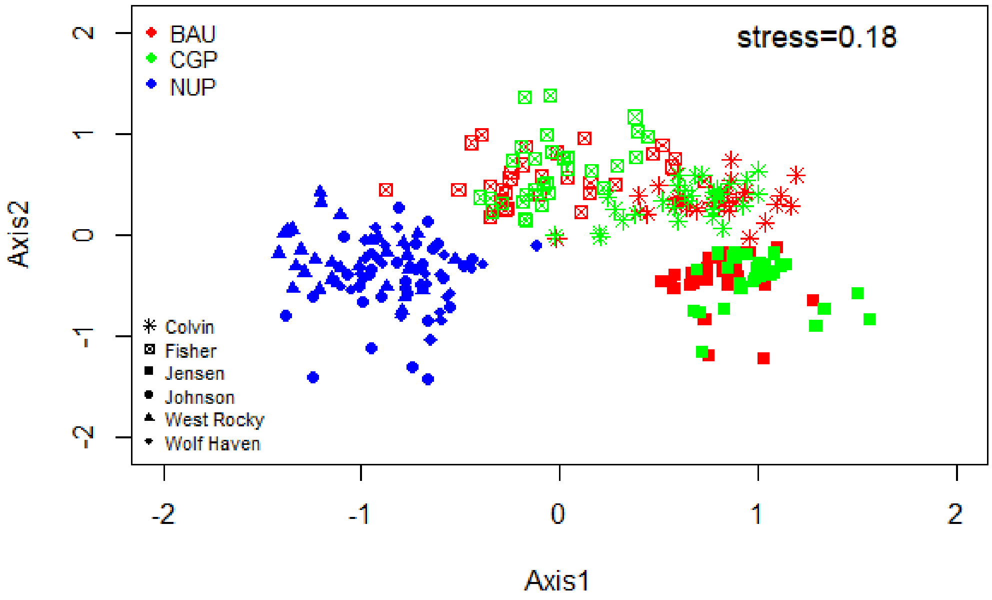

Figure 14. Non-metric multidimensional scaling (NMDS) ordination of plant communities in 2019. Each point represents the plant community in a single monitoring plot. Study sites are represented by different shapes while treatments are denoted with varying colors. The stress value indicates how well the data are represented by the ordination with stress = 0.18 indicating a fair representation.

Percent cover of native forbs and forage species

One year after the implementation of conservation grazing practices (CGP), there was no significant difference in native forb cover (p=0.08) or forage species cover (p=0.1) compared to BAU practices (Figures 15, 16). Not surprisingly, native ungrazed prairies varied considerably from ranch sites in these two metrics with higher native forb cover (p<0.001) and lower cover of forage species (p<0.001).

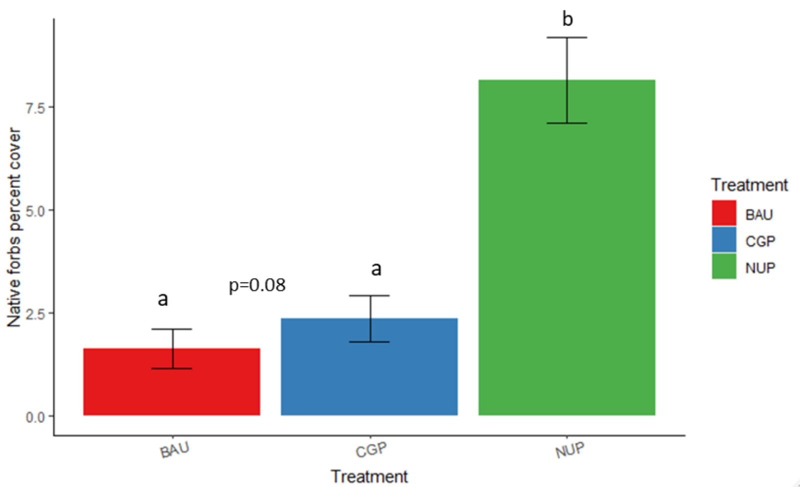

Figure 15. Average percent cover of native forbs species across treatments in 2019. P values are from Kruskal-Wallis tests.

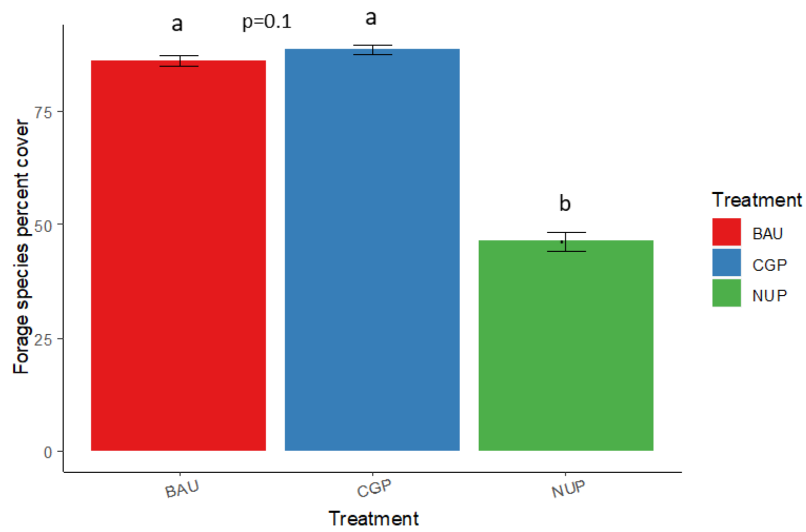

Figure 16. Average percent cover of forage species across treatments in 2019. P values are from Kruskal-Wallis tests.

Gopher Occupancy

Gopher activity increased over 2018-2019 at all sites except Johnson prairie which decreased by 9% (Figures 17, 18). The greatest increases occurred at ranch sites (Colvin=+16%; Fisher=+25%; Riverbend=+38%). Portions of the native ungrazed prairie sites were burned in 2019, which could explain the mixed results (i.e., decrease at Johnson prairie) and tempered increases in gopher abundance at other native ungrazed prairie sites (Wolf Haven=+2%; West Rocky=+7%). Plots that burned in 2019 did have lower occupancy rates, but sample sizes were low compared to unburned plots (Figure 19). Examining changes across treatments over 2018-2019, BAU increased from 38-66% while CGP increased from 60-76% (Figures 10, 11). Native ungrazed prairies showed no overall change over 2018-2019.

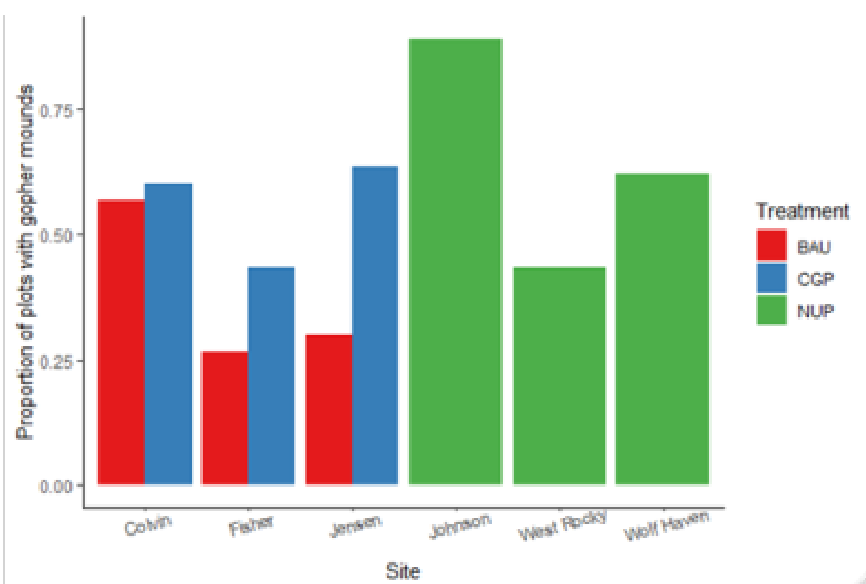

Figure 17. Proportion of monitoring plots occupied by gophers in 2018 across all sites and three treatments (n=30).

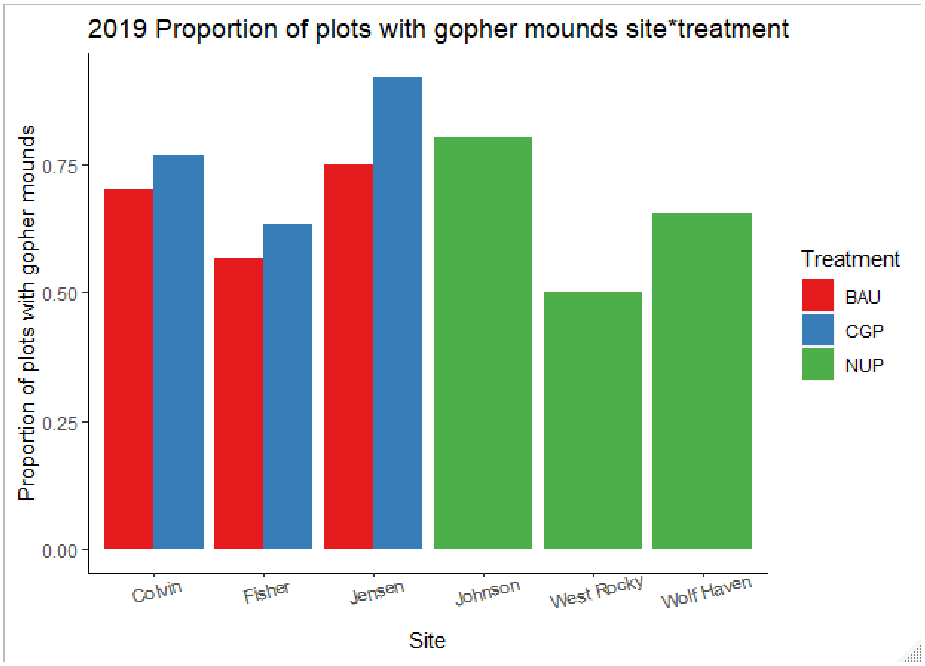

Figure 18. Proportion of monitoring plots occupied by gophers in 2019 across all sites and three treatments (n=30).

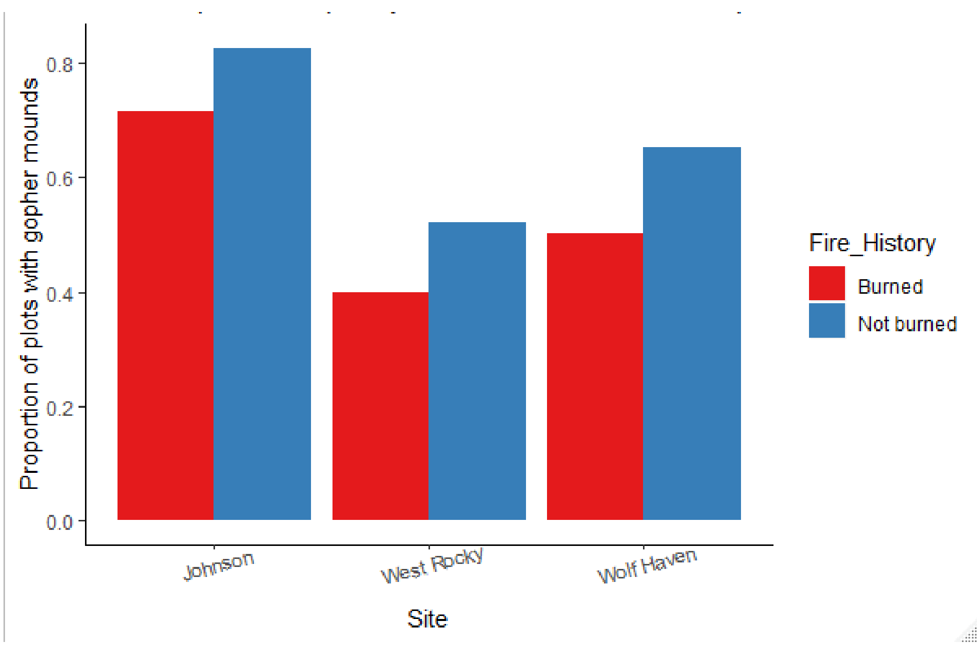

Figure 19. Gopher occupancy at native ungrazed prairies in plots that were burned versus not burned in 2019. Sample sizes were as follows: Johnson burned (n=7), Johnson unburned (n=23), West Rocky burned (n=5), West Rocky unburned (n=25), Wolf Haven burned (n=6), Wolf Haven (n=23).

Forage biomass
Biomass production ranged from 0.49 to 1.76 tons per acre for ranch sites, and from 0.53 to 0.61 tons per acre for upland prairie (Figure 20). Biomass production in 2018 and 2019 was generally the highest on the rotational grazed ranch site, Colvin Ranch. Having corrected for the missed fall biomass sampling at Riverbend in 2018, the 2019 estimation was more closely aligned with Colvin Ranch. Due to higher stocking rates, Fisher Ranch was generally unable to implement a rest period between grazing rotations, resulting in lower biomass production (Figure 20). Additionally, low productivity at Fisher Farm may be linked to lower phosphorus and potassium levels at this site (Table 5).

A notable development in 2019 was increased production in CGP treatments at Riverbend Fisher ranches. Non-significant trends showed generally higher production in these treatments. On the other hand, CGP biomass totals that were *no less* than BAU totals indicate there was no detrimental effect of seeding native species into pastures. In the future, any significantly greater biomass production in the rotational treatment at Riverbend over the continuously grazed treatment could indicate the benefits to producers of this conservation grazing practice.

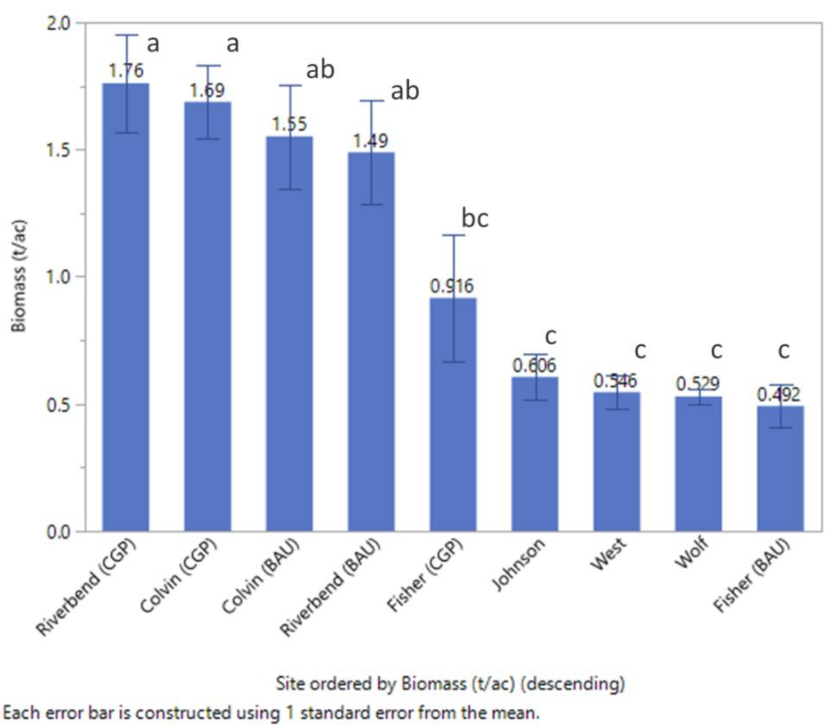

Figure 20. Total biomass production measured across sites and treatments.

Lower biomass production at the ungrazed prairie sites (Johnson West Rocky, and Wolf Haven) in relation to Colvin and Fisher may be due to lower nutrient levels at these sites, in particular phosphorus and potassium (Table 5). Another factor may be soil moisture. Forage and soils work in 2020 may include forage quality assessment, soil compaction and soil temperatures, to evaluate the potential impacts of grazing generally, conservation grazing in particular, and lack of grazing on these forage quality and soil health parameters.

Table 5. Soils Nutrient Data Collection in 2018 as Expressed as the Sample Mean ± 1 Standard Deviation.

Habitat Metric	Variable	Farm sites			Upland Prairie Sites		
		Colvin	Fisher	Riverbend	Johnson	West Rocky	Wolf Haven
Soils	Nitrogen (NO3-N) ppm	8.16 ± 3.06	11.16 ± 4.79	6.16 ± 1.60		12.50 ± 7.12	8.33 ± 0.82
	Phosphorus (Weak Bray) ppm	49.83 ± 23.72	5.16 ± 6.11	99.83 ± 30.29		1.00 ± 0.00	2.00 ± 2.45
	Potassium (K) ppm	93.00 ± 27.68	63.33 ± 18.81	135.50 ± 34.51		53.00 ± 3.90	65.17 ± 10.61

Forage Utilization

A take-half/leave-half approach to forage utilization is generally encouraged in rotational grazing systems. While it requires ranchers to forego usage, leaving forage allows for greater biomass productivity as a result. Percent forage utilization provides an indication of the extent to which this strategy is implemented by different ranch operations.

Forage utilization was apparently greater at Colvin and Fisher ranches (Figure 21), yet statistical analysis is not complete. Utilization at these two sites is likely not significantly different, even given the lower 62% rate at Colvin BAU. Riverbend Ranch exhibited the lowest utilization rates. As noted in the Methods section, utilization estimates are fraught with opportunity for error due to considerable variability and differences in utilization data collection methods and calculations between rotationally and continuously grazed sites. Clipping heights (data not shown), and consequently per sample biomass amounts (monthly for Riverbend, June-September before-after for Fisher) at these two sites (both BAU and CGP for Fisher and BAU only for Riverbend) were so low that large variations in utilization could have been easily introduced into the resulting data.

Fisher Ranch tended to be generally grazed very low (despite some rotational grazing through paddocks), similar to continuous grazing in Riverbend BAU. Consequently, it is not clear why utilization rates were low at Riverbend as compared to Fisher when Riverbend BAU forage height was similarly and consistently low in stature. Relatively low utilization (50%) in Riverbend CGP was due to an initial paddock installation, and considerable forage trampling/wastage by livestock. Given similar forage trampling was observed at Colvin Ranch, the higher utilization there was surprising. Additional analysis is required, and forage utilization may not be a practical measure to obtain at these particular sites.

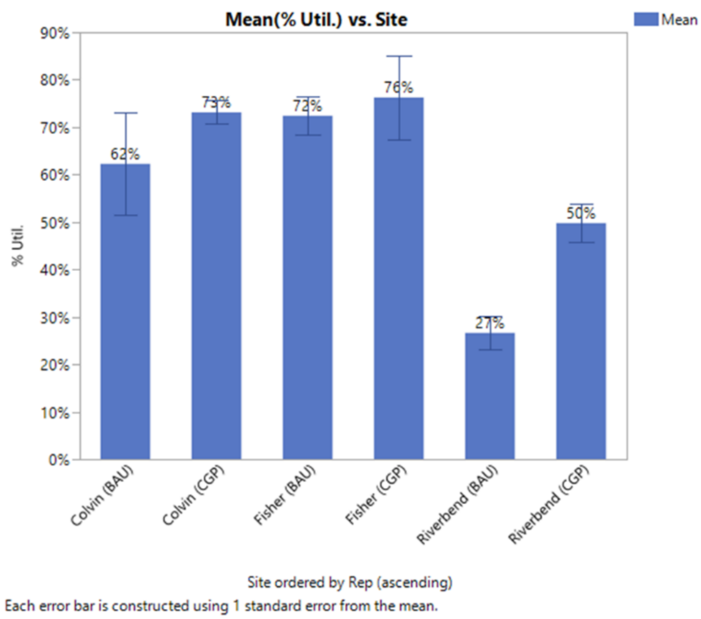

Figure 21. Estimation of forage utilized during 2019, as measured by the difference in forage biomass between cage and no-cage area in the continuously grazed system (Riverbend BAU), and before-after sampling in the rotationally grazed systems (Colvin and Fisher CGP and BAU).

2019 Butterfly Behavior Results

In 2018 a total of 122 butterfly observations were obtained throughout the season (see Table 6 for more detail). A goal of five male and five female observations per site for silvery blue butterflies (*G. lygdamus)* at all sites except one was achieved. A goal of five male ochre ringlet butterfly (*C.t. eunomia)* paths per site in the early season at all sites except one was also achieved.

Female *C.t. eunomia* are more difficult observe as they are skittish and sedentary. This limited the number of observations that could be completed. In the late season, weather limited progress, as it was unusually cloudy and extremely windy in the afternoons. A total of 22 total *C.t. eunomia* paths in the late season were obtained.

Table 6. The total number of observation paths obtained per site separated by species and sex. *C.t. eunomia* is further separated by the flight period in which the observation was collected. The early flight ran May-July and the late flight ran July-September. *G. lygdamus* has only one flight period (May), so the data is not separated by flight period.

	C. tullia eunomia				*G. lygdamus*		Total per site
	Female		Male		Female	Male	
Location	Early	Late	Early	Late			
Colvin Ranch	1	1	5	3	5	4	19
Johnson Prairie	2	1	5	3	7	6	24
Mary Mallonee's Farm	1	1	3	3	5	5	18
Maynard Mallonee's Farm	1	2	5	0	5	4	17

Riverbend Ranch	2	1	5	3	6	5	22
West Rocky Prairie	3	2	4	3	5	5	22
Total per sex per species	10	8	27	15	33	29	122

2018 Butterfly Behavior Results

In 2018, silvery blue females may have been affected by grazing, as indicated by diffusion rates that were much lower in the ungrazed native upland prairie sites (Figure 22). This was an indication of the concentrated search patterns exhibited in areas with high reward. Silvery blue males did not appear to differ in their diffusion rates. Ochre ringlets did not exhibit a trend in diffusion rates across management types, regardless of sex (Figure 23). These methods will be repeated in 2020 to gather final experimental data. It is expected that a larger sample size will reveal more pronounced trends in diffusion rates across management types.

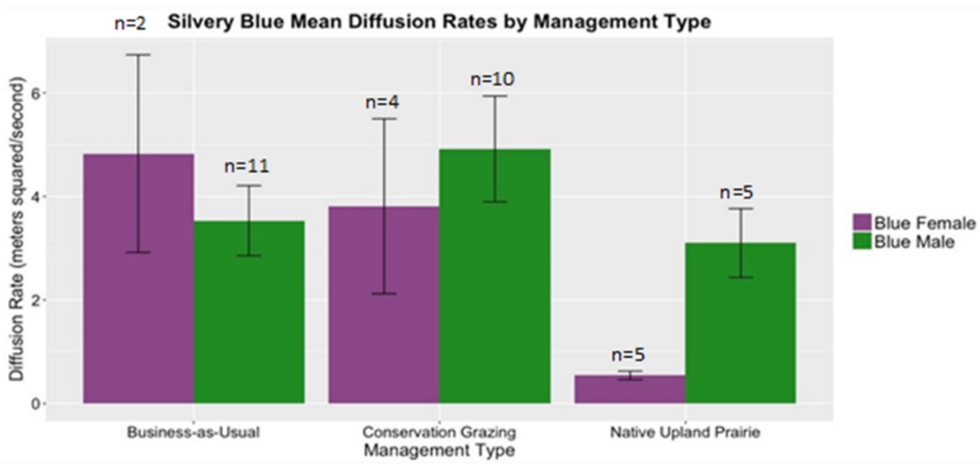

Figure 22. Mean diffusion rates of male and female silvery blue butterflies under each management type.

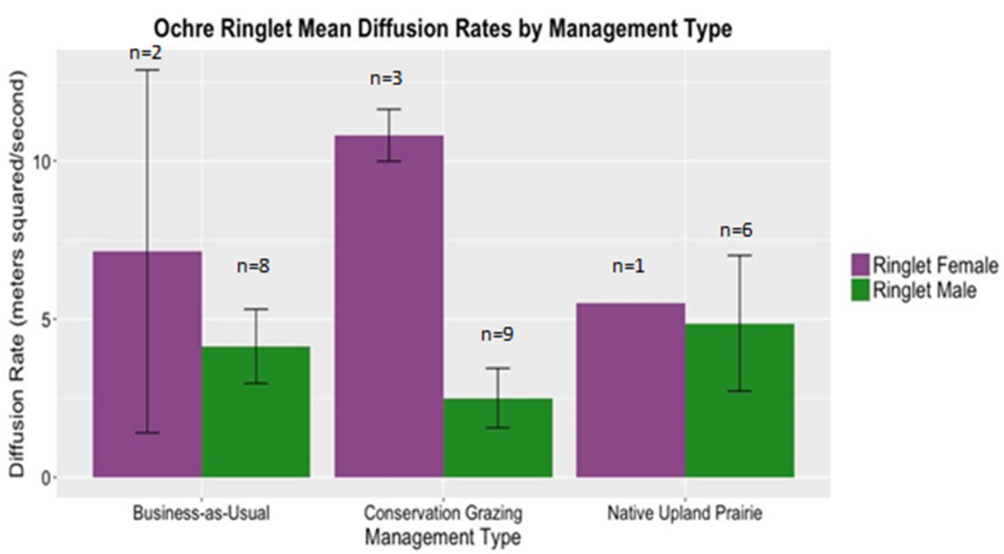

Figure 23: Mean diffusion rates of male and female ochre ringlet butterflies under each management type.

Soil taxonomic work

The majority of soil profiles at ranch and prairie preserve sites classified as either a Spanaway (Typic Humixercept) or Nisqually (Pachic Humixerept) series, or a higher-taxa of Pachic Humixercept (i.e., there is no existing soil series that would be a good fit). In general, the Spanaway-like soils were found in intermound areas, and the Nisqually-like soils were found on the mound sites that had a deeper, darker surface horizon(s). The higher-taxa Pachic Humixerepts, were described as Loamy-skeletal as compared to the sandy Nisqually, or sandy-skeletal Spanaway, meaning it had slightly more clay content within the control section. One outlier was a poorly drained, Norma soil found near a drainage ditch on one of the ranch research sites.

Based on these sites, a fairly clear pattern of deeper, more organic rich surface A horizons found on mounded areas and thinner A horizons found in the intermound position emerged. In addition, the mounded areas generally had either less rock fragment content by volume and/or smaller rock fragment diameter within the surface A horizons. In general, soil pit descriptions mostly conformed (though did not capture the higher taxa) to soil units mapped on NRCS Web Soil Survey (Table 7). Full soil pit descriptions are available upon request.

Table 7. Mapped soil series and soil series as verified by soil pit descriptions at ranch and prairie preserve research sites.

Site	Mapped soil series	Soil pit description	Notes
West Rocky	Spanaway Nisqually complex	Mound: Nisqually or higher order taxa Intermound: Spanaway	Mound land form resulted in loamier soil (slightly higher clay and silt content) than typical Nisqually
Wolf Haven	Spanaway Nisqually complex	Mound: Nisqually Intermound: Spanaway	
Johnson Prairie	Not complete	Not complete	
Riverbend	Nisqually	Upland pit: Nisqually Pit near drainage: Norma	Clay, loam content not elevated as in higher taxa Pachic Humixerept.
Colvin	Spanaway Nisqually complex	Mound: Nisqually or higher order taxa Intermound: Spanaway	Mound site with elevated clay and silt content in A1 horizon
Fisher	Spanaway Nisqually complex	Upper field: Nisqually or higher order taxa Lower field: Nisqually or higher order taxa	Both sites with elevated clay and silt content in A1 horizon
Maynard Mallonee	Alvor, Reed, Chehalis, Newberg	Not complete	

Survey of Grazing Practices in Southwest Washington
In a survey of grazing practices in southwest Washington, a total of 132 responses were received, 95 of which were from the emailed link and 42 from the printed surveys. The team is working with the email lists of partner organizations who helped distribute the survey link, to calculate the total recipients targeted and consequent response rate. Ninety-two of the responses were from producers who have livestock and 38 were from producers who do not. Two respondents did not answer the question about whether they had livestock.

Initial data exploration suggests that many producers are interested in some form of conservation, but have apparent preferences (Figure 24). They are generally concerned about the presence of endangered species limiting their development rights. The survey data will be fully analyzed in 2020.

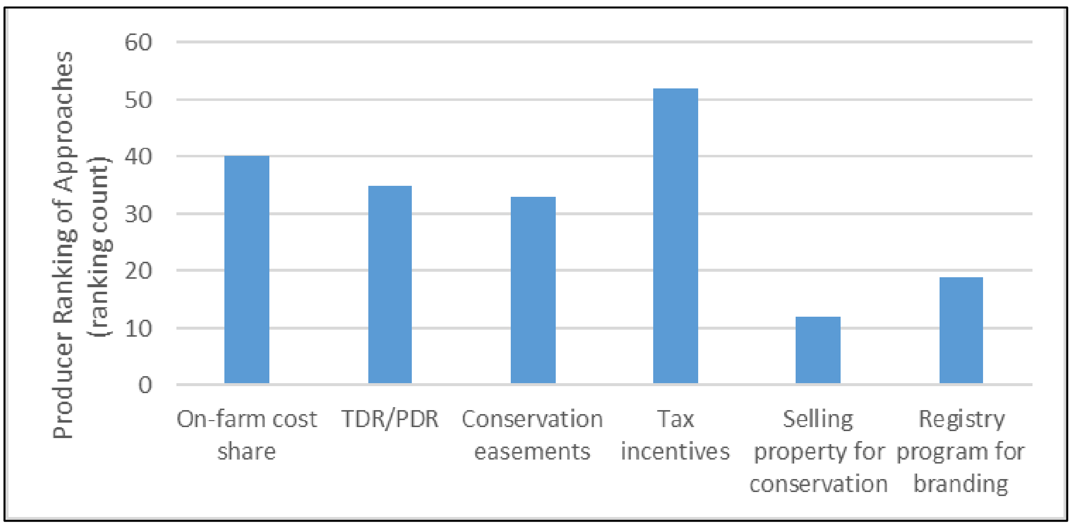

Figure 24. Interest among landowners in different approaches to conservation on working lands. Data in this preliminary analysis only included email responses. Cost-share programs can refer to those such as NRCS EQIP grants; "TDR/PDR" refers to 'transfer of development rights', and 'purchase of development rights' programs, and are programs for landowners to benefit financially by retiring rights to develop their property; conservation easements can restrict the kind of farming activity on property, or require additional conservation activities; tax incentives can include tax breaks for keeping land in production, or a particular conservation use; registry program for branding can include a "prairie safe", or "prairie friendly" label that could attract premium pricing.

Educational and Outreach Activities

Three on-farm workshops were held in 2019 with 98 participants (14 attendees in the spring, 61 in the summer, and 23 in the fall). Seventy-one percent of attendees rated themselves with moderate to advanced experience with raising livestock. Fifty-five percent rated themselves with moderate to advanced experience with habitat conservation. Ninety to ninety-two percent of attendees indicated they would use the information learned at the field day, consisting of knowledge of and skills for applying rotational grazing, use of the Pasture Calendar (an NRCS publication) for planned grazing, fencing systems, grazing systems for habitat, native plants in grazed systems, and butterflies in grazed systems. Ninety percent of attendees rated the events as very useful, and 10 percent as somewhat useful.

Consultations:

Two consultations were held in 2018, focused mostly on gaining farmer feedback and input on economic and social aspects of conservation grazing practices.

- *Economic cost/benefit consultation:*
    - We gathered economic data on grazing operations that will be used to complete a *Fifty Head Cow-Calf Grazing Enterprise Budget in South Puget Sound.*
    - Three of our farmer-cooperators, and two additional farmers participated.
- *Farmer survey review & consultation:*
    - We gathered feedback on a draft farmer-rancher survey evaluating perspectives on conservation programs for working lands.
    - Three of farmer-cooperators and two additional farmers participated.

Two consultations were held in 2019

- A follow-up review of the cow-calf and grass-finished steer budget with farmer cooperators
- A review of the budget with Thurston County Agriculture Committee members

Curricula, factsheets or educational tools

- Factsheet in progress

Journal articles

- None yet

On-farm demonstrations

- Fisher, Colvin, Riverbend

Published press articles:

- Olympian article with information on HCP and prairie grazing study and workshop
- Newsletter information in WSU Ag Sounder

Tours

- ?

Webinars, talks and presentations:

- Bramwell, S. 2019. Evaluation of Grazed and Ungrazed Prairie Land for Species Protection in Western Washington. Tilth Producers Conference of Washington. November 10th. 20 attendees.

- Habernicht, M. 2019. Native plant habitat on grazed and ungrazed working lands. Tilth Producers Conference of Washington. November 10th. 20 attendees.
- Bussan, S. 2019. Butterfly Behavior Research, Case Studies on the Effects of Grazing in Europe, and Methods Demonstration for Evaluating Butterfly Behavior. Thurston Conservation District Workshop. 15-20 attendees.
- Bussan, S. 2018. Can conservation grazing maintain habitat quality for butterflies? Presentation at the Entomological Society of America Conference. Vancouver, BC.
    - The topic involved butterfly behavior in grazed and ungrazed prairies. The results and figures presented in this talk are included in this report (Figure 16).
    - Audience included professionals in the fields of entomology and ecology. Approximately 30 ppl in attendance.
- Bussan, S. 2018. A review of the literature on butterflies and cattle grazing. Presentation and panel discussion at the Cascadia Prairie Oak Partnership. Eugene, OR.
    - Presentation covered the current and past literature on butterflies and cattle grazing as a framework and introduction for a session on cattle grazing in PNW prairie ecosystems.
    - Audience included scientists and other professionals in the field of prairie ecology. Approximately 100 ppl in attendance.

<u>Workshops, field days</u>

- Spring, summer, fall 2019

Other educational activity

<u>Number of farmers who participated in research</u>

- 30 farmers attended grazing workshops in 2019.
- 130 farmers participated in the survey of grazing and on-farm conservation practices in southwest WA (92 livestock producers, and 38 non-livestock producers)
- 8 farmers in the Thurston County Agriculture Committee provided feedback on the research project and received regular updates, assisting in guiding workshop content and outreach
- Approximately 200 farmers received three research updates in 2019 regarding the project through the WSU Ag Sounder newsletter
- 4 farmers directly cooperated in 2018 and 2019 field-based research
- 3 of those farmers plus 2 additional consulting farmers participated in the fall 2018 Delphi Method economic interviews to gather data for grazing enterprise budget development, as well as to provide responses on a farmer-rancher survey that will be circulated in 2019.
- 177 total farmers participated in education and outreach activities (not counting those who received the Ag Sounder newsletter, but those directly involved).

Learning outcomes

- 54 Farmers reported changes in knowledge, attitudes, skills and/or awareness as a result of their participation

Key areas taught:

- What rotational grazing is
- Skills for applying rotational grazing
- Existence of pasture calendar as a planning tool
- Fencing systems
- Grazing systems that improve habitat
- Native plants in grazed systems
- Butterflies in grazed systems

Key changes:

- What rotational grazing is (85%, 54 farmers)
- Skills for applying rotational grazing (80%, 50 farmers)
- Existence of pasture calendar as a planning tool (90%, 57 farmers)
- Fencing systems (95%, 60 farmers)
- Grazing systems that improve habitat (89.5%, 56 farmers)
- Native plants in grazed systems (75%, 47 farmers)
- Butterflies in grazed systems (80%, 50 farmers)

Number of farmers/ranchers who report changes in knowledge, attitude, skills and/or awareness

Key knowledge and skills that were taught through the project

Project outcomes

- Number of farmers who intend to change their practices:
- Number of farmers who intend to use the knowledge/skills gained: 57

- Additional grants received that built upon this project (for project leader, cooperators and/or beneficiaries):
    - C. Schultz, WSU-Vancouver - Received a CEREO grant to support a portion of S. Bussan's time

- New working collaborations:
    - Sentinel Lands working group in Olympia, WA
    - WSU Kittitas County Extension

There are approximately 15,319 acres of permanent pasture and rangeland in Thurston County, down 27% between 2012 and 2017 from 21,113 acres. Thurston County is at the southern terminus of the Seattle-Tacoma-Olympia metropolitan region in South Puget Sound, and is experiencing rapid development pressure. Requirements to protect endangered species, on droughty soils typically underlaying pasture and rangeland, adds additional pressure to remove grazing land from production. This project provides County decision makers and state and federal Fish and Wildlife departments data to evaluate the potential of grazing lands to contribute to conservation outcomes without removing it from production.

In 2018 and 2019, annual reports were provided to Thurston County Community Planning, and the US Fish and Wildilfe to contribute local data to development of a Habitat Conservation Plan to preserve several listed threatened and endangered species. The Thurston HCP could utilize as much or more than 2,500 acres of working grazing land of the total approximately 5,000 mitigation acres needed, mostly for Mazama Pocket Gopher habitat, but for other species (such as Vesper Sparrow, Taylors Checkerspot Butterfly, and Streak Horned Lark) as well. The report data to date, among other findings, indicates that Mazama Pocket Gopher occupancy is not necessarily native vegetative dependent as both the CGP ag site and the NUP site had better than 50% MPG occupancy and the native vegetation for the CGP ag site was quite low. This assists with the credit-debit methodology work with USFWS about what habitat features to value when determining functional value of a site. This enables working grazing land to be utilized in meeting HCP requirements, keeping more land in agriculture, while also providing opportunity to improve the conservation value of these lands.

In particular, data and findings from this research are helping to inform proposals to acquire funding for conservation easement acquisition, while results from the Grazing Lands Survey conducted will inform the kind of conservation programs farmers are mostly likely to participate in. Current development of a funding proposal with project partners, and a local Sentinel Lands group (or other funding) will provide outreach capacity to provide farmers with information they need to participate in voluntary conservation programming such as easements, transfer of development rights, cost-share efforts, or other programs.

Two project co-PIs and a project collaborator at NRCS worked with US Fish and Wildlife to develop an "Easement Staircase", or ranking tool to determine the conservation value represented by grazing lands employing an increasing intensity of conservation practices.

Success Stories

Recommendations

Appendix A. Site Maps

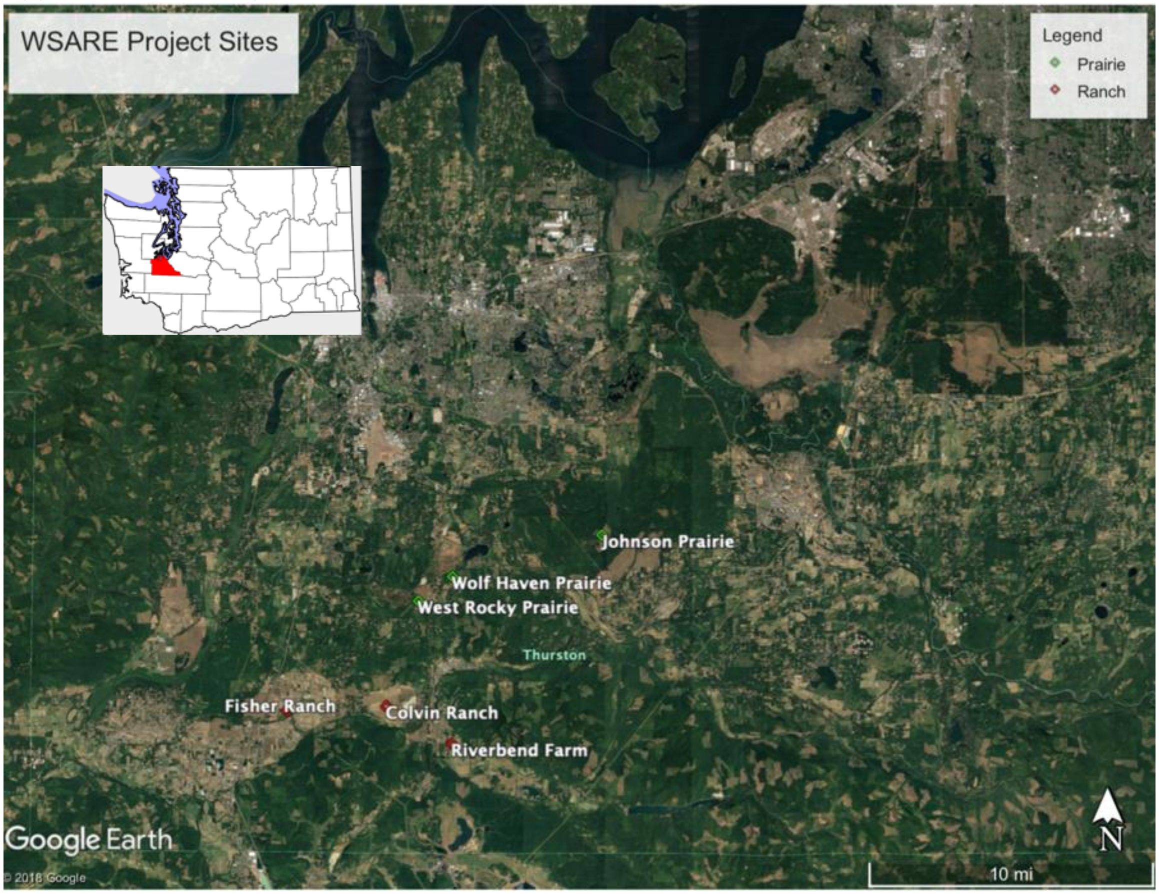

Figure 1. Location of all ranch sites and native upland prairie sites within Thurston County, Washington State, USA.

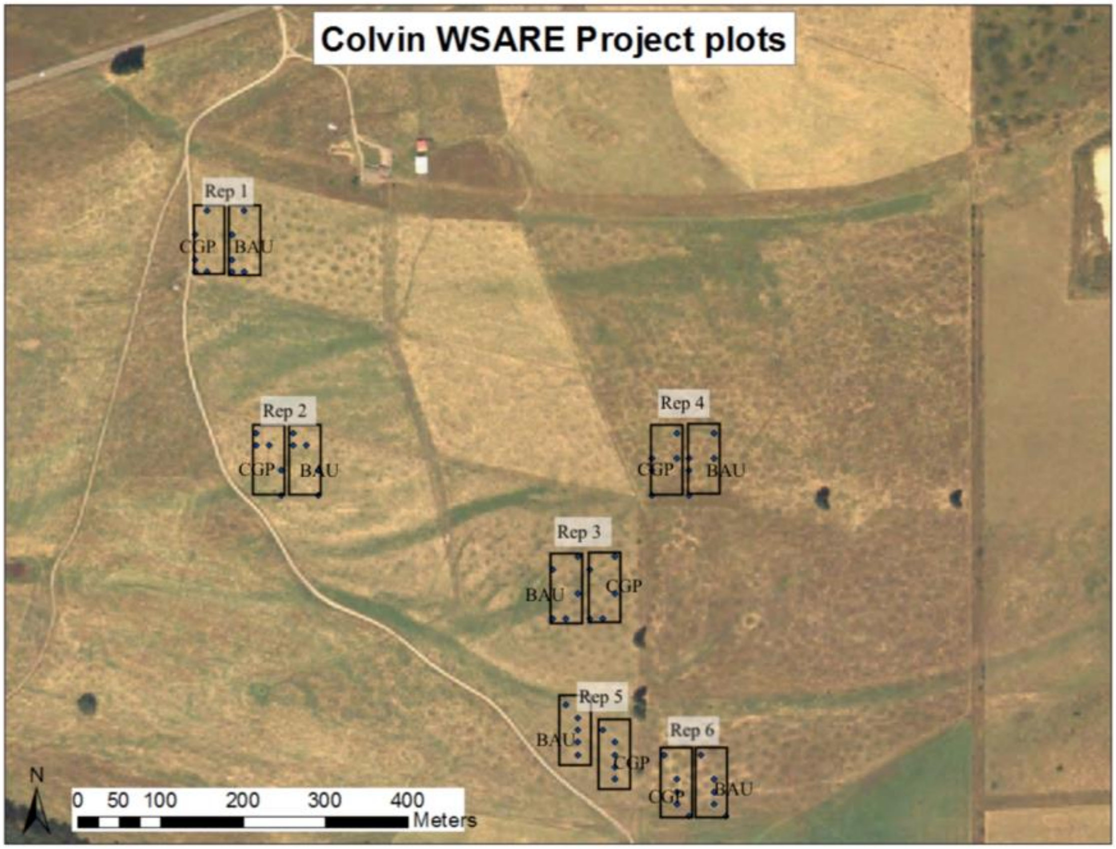

Figure 2. Replicate 1-acre CGP and BAU paddocks at Colvin Ranch

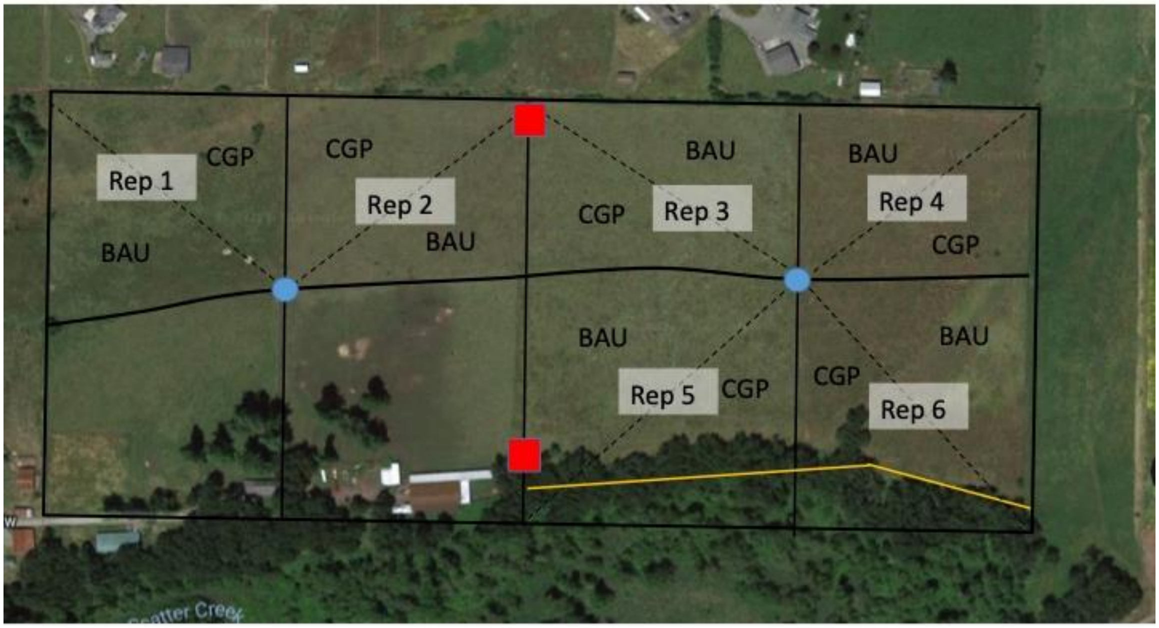

Figure 3. Replicate 1-acre CGP and BAU paddocks at Fisher Ranch

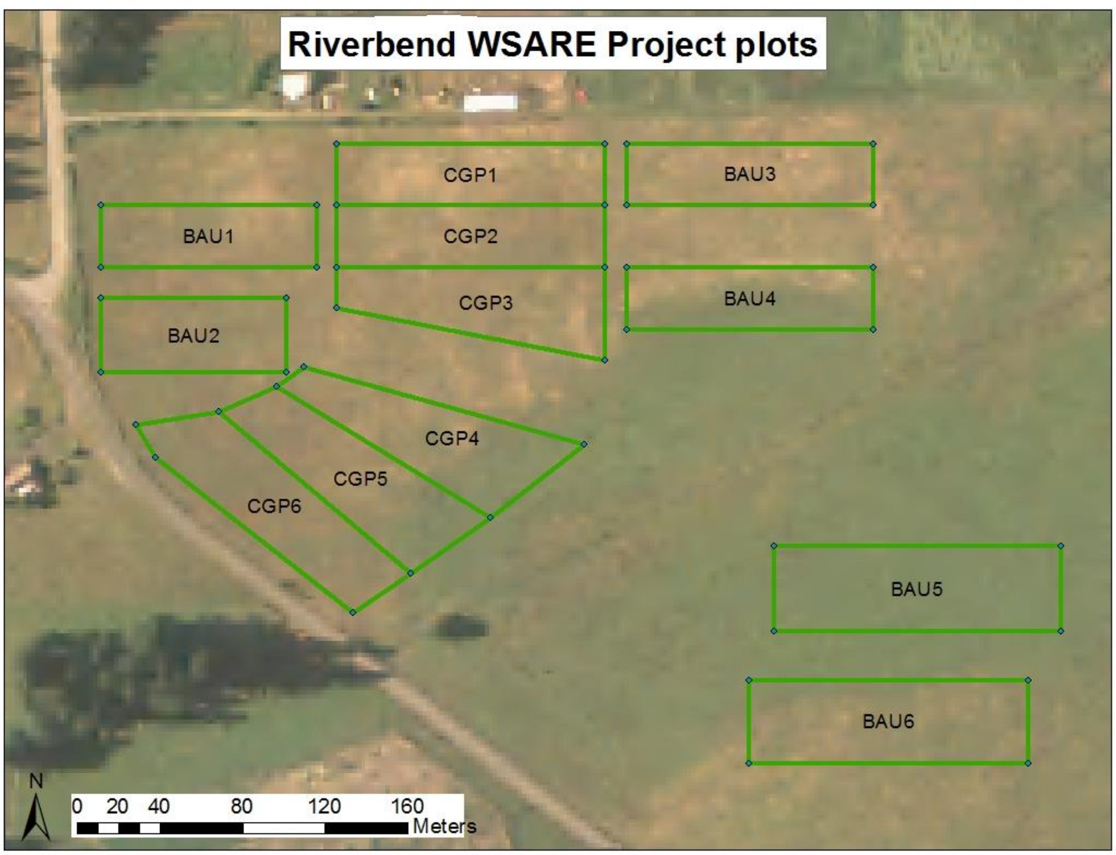

Figure 4. Replicate 1-acre CGP and BAU paddocks at Riverbend Farm

Appendix B. Species seeded into farm sites, along with life history and seeding rates

Scientific Name	CODON	Common Name	Family	Life History	Sites where seeded	Seeding Rate (lbs/acre)	PLS/m^2
*Castilleja levisecta**	CASLEV	Golden paintbrush	Orobanchaceae	Perennial, hemi-parasite	Colvin, Riverbend	0.350	297.589
Cerastium arvense	CERARV	Field chickweed	Caryophyllaceae	Annual	Fisher, Colvin, Riverbend	0.022	13.916
Collinsia parviflora	COLPAR	Maiden blue-eyed Mary	Scrophulariaceae	Annual	Fisher, Colvin, Riverbend	0.153	12.436
Eriophyllum lanatum	ERILAN	Oregon sunshine	Asteraceae	Perennial	Riverbend	0.059	16.768
Lomatium triternatum†	LOMTRI	Nineleaf biscuitroot	Apiaceae	Perennial	Fisher, Colvin, Riverbend	0.353	5.205
Lupinus bicolor	LUPBIC	Bicolor lupine	Fabaceae	Annual, legume	Fisher, Colvin, Riverbend	0.246	5.182
Microseris laciniata	MICLAC	Cut-leaf microseris	Asteraceae	Perennial	Fisher, Colvin, Riverbend	0.062	6.093
Plectritis congesta	PLECON	Sea blush	Caprifoliaceae	Annual	Fisher, Colvin, Riverbend	0.110	17.646
Ranunculus occidentalis	RANOCC	Western buttercup	Ranunculaceae	Perennial	Fisher, Riverbend	0.213	9.621
Viola adunca	VIOADU	Hookedspur violet	Violaceae	Perennial	Fisher, Colvin, Riverbend	0.113	16.864

* Only seeded CASLEV into 3 of the paddocks at Colvin and into 6 plots (1 per paddock) at Riverbend due to limited seed availability. Seeding rate of CASLEV at Riverbend was slightly higher than other sites: 309 PLS/m^2; PLS = Pure Live Seed

† Only seeded into plots, not the entire paddock, at Fisher due to limited seed availability