1

Post-fire Vegetation Recovery and Restoration in Response to Livestock Grazing

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Abstract

The goal of the project is to 1) assess vegetation recovery across environmental gradients, management type, and burn severities, 2) determine the differences in presence and absence of active restoration with seedballs and naked seed, and 3) assess effects of grazing post-fire on plant communities. Plot locations were determined based on fire severity (moderate and light), ecological site (loamy slopes and limestone hills), slope (20-30% and 30-40%) and aspect (south and northwest). Paired plots in areas with grazing immediately after the fire and with no grazing will be used to determine effects of post-fire grazing on vegetation recovery by comparing frequency, ground cover, and species composition. To better understand restoration options for semiarid environments seedballs and naked seed were deployed before monsoon season of 2022 in grazed and ungrazed 4m2 plots. At the conclusion of monsoon season germination rates will be determined. We hope to determine if hoof action aids in getting seed into the soil and potentially increase germination rates. We also aim to establish if seedballs will have higher germination rates than naked seed, therefore increasing the chance of successful restoration and vegetation recruitment post-fire.

2

Introduction to VGS Online

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Abstract

VGS is a free software application designed for recording and managing ecosystem sampling data. The application provides a data repository for organizing and managing information associated with an unlimited number of study sites and an electronic tool for recording data in the field. With the recent development of VGS Online, pairing the two applications allows for rapid analysis at local, landscape and global scales and better-informed decision making. VGS Online is a map-enhanced secure web interface to the data server. In addition to the standard VGS file structure, VGS online takes navigation within the database to the next level by allowing users to view, select, and report on sites from an ArcGIS webmap. These map features are also available in the filter tool and provide a mechanism for spatial refinement. Map- or tabular-based searching and filtering of data results offer users flexibility on how they want to query data. This delivers maximum flexibility in data analysis and reporting. Users can still manage a host of capabilities such as: the organization of sites and date, available protocols, GPS locations, and photos.

3

Let's Go Brandin': An Ethnographic Look at Family, Community, and Ranching Practices in New Mexico's High-Low Country

Ken C. Erickson

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Abstract

Preliminary ethnographic fieldwork conducted in the Summer of 2022 in and around Union and Colfax county ranch country—the "High-Low" country of Northeast New Mexico—is reported here. This multi-year work, partially funded by grants from the Provost's Office of the University of South Carolina and by the U of SC Darla Moore School of Business, echoes the calls by many in the range management community for detailed, long-term engagement with communities to better understand what is going on with people and cattle in real-life settings. This presentation will briefly outline the limitations, strengths, and ethical implications of long-term, collaborative ethnographic work in market-based pastoralism. An ethnographic narrative and photographic vignette—from a branding with an extended "legacy" ranch family at the working pens on a high-altitude summer pasture—sets the stage for a discussion of several issues. Among them are management decisions and family succession; the realities of rural, off-ranch employment; youth socialization and ritual in ranching practices; gender differences in ranch-work; emerging cattle marketing strategies; and definitional questions about ranching and ranchers that emerge when the scholarly literature is compared to the realities of daily life in ranching communities. The presentation will conclude with thoughts on the generalizability of questions—and answers—derived from long-term, collaborative ethnographic work on North American ranching as seen through an anthropological lens.

4

Multivariate analysis to Distinguish Indigenous Cattle in North Shewa zone of Oromia, Ethiopia

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Abstract

Abstracts

The study was conducted to characterize indigenous cattle in north Shewa zone of Oromia using morphometric traits by applying multivariate analysis. Multistage purposive sampling technique was used based on the potential of cattle production and agro-ecology of districts. Accordingly three districts (Degem, Kuyyuu and Wuchale) that encompasses the highland, midland and lowland agroecology; and recognized with higher cattle potential were selected. A total of 399 matured indigenous female and male cattle of 4 age categories were sampled. Morphometric data collected from sampled cattle were analyzed using SAS version 9.4. Mean separation of ANOVA was made by Duncan multiple range test (DMRT) at $P<0.05$ significant level to compute GLM on independent factors. Multivariate analysis including cluster, stepwise discriminant, canonical discriminant analyses were used to determine morphological similarity or divergence among the indigenous cattle populations in the three agroecology. The GLM indicated, most of morphological traits were significantly ($p<0.05$) different on fixed factors except the districts. The cluster analysis grouped cattle in two clusters; where the first cluster include highland population and the second contain midland and lowland together. The stepwise discriminant analysis revealed 11 traits among 14 had potential and have significant ($p<0.0001$) discriminating power as confirmed by Wilk's lambda test and partial R2 value. Longer (9.81) and shorter (3.35) square mahalanobis distance were computed by highland Vs lowland and highland Vs midland agroecology respectively, and all distances were significant ($p<0.001$). Based on the discriminant analysis 90.4% of highland, 73.6% of midland and 74.2 % of lowland indigenous cattle population were classified in their original population and the corresponding remaining were found out of their source population. The current study result could be valuable to support the indigenous cattle genetic improvement and conservation in their production environment as well as their sustainable utilization.

5

Physiological features reactivity of Arsi-Bale goats reared under the three agro-ecologies of the Bale zone, southeastern Ethiopia

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Abstract

The study aimed to evaluate physiological features responsiveness of Arsi-Bale goats reared under the three agro-ecologies for the effects of season, sex and age groups. Data were collected from 90 goats kept in a free-range milieu. Data were recorded on bioclimatic and live body weight. SAS, 2012 vr.9.4 were used for analyses. The impacts of climatic and physiological variables were significantly different ($p<0.05$) among agro-ecologies in dry and wet seasons. The thermal effect magnitudes were varying existed severe and extremely severe conditions across season. The effects of thermal load were non-significant ($p>0.05$) for sex while significant ($p<0.05$) for age groups. The reactive response indicator thermal indices were highly significant ($p<0.05$) across a season and agro-ecologies. More, heat tolerance index varied experiencing moderate to severe stress during wet and dry season affecting significantly weight gain performances ($p<0.05$) for cold and hot stress, respectively. The comfort bioclimatic condition indices of general, effective and practical's were highly significant ($p<0.05$) among agro-ecologies across seasons. As well, the comfort environment indices of general, effective and practical's were highly significant ($p<0.05$) across seasons and among agro-ecologies. The comfort bioclimatic conditions were highly correlated with physiological responses for their impacts in production ecology. But, heat tolerance coefficients were negatively correlated due to biotic sways on growth rate. Therefore, the study concluded that in order to maintain yield by providing a suitable habitat for ecotypes, production ecologies require interventions during cold stress for night shelter and feeding strategies to reduce heat exposure promptly and offer supplementary feed.

Keywords: Pulse rate, rectal temperature, relative humidity, respiration rate, thermal indices

6

Granivorous ants prefer small and unprotected seeds—implications for restoration in arid rangelands

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Abstract

Successful seed-based restoration in dry rangelands is difficult due to the many limitations associated with germination and establishment. Seed predators, including granivorous ants, can consume or move applied seeds offsite reducing restoration success. Granivorous ants in the U.S. southwest move and store tens of thousands of seeds and show preferences for seeds based on weight, size, nutrient content, and novelty. In this study, we examine which seed traits most influence seed predation rates in a southwestern Arizona rangeland. We presented 24 seed types from native species with restoration value in three cafeteria-style selection areas installed adjacent to Pogonomyrmex nests. We also installed pitfall traps to assess the diversity of ant species that may have visited the cafeterias. Our results showed that among offered seeds, 3–99% were collected by granivorous ants, with small seeds and those with no structure the most preferred. Across all cafeterias, we had 11 ant species in our pitfall traps, with over half of those being known seed predators. From our study, we found that seed traits do influence ant seed preference and our results can help inform practices that could aid in keeping seed on the ground and increasing the chance of germination and establishment.

7

Drought effects on plant species composition and root biomass in a Kentucky bluegrass Invaded northern Great Plains rangeland

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Abstract

Kentucky bluegrass (*Poa pratensis* L.), an invasive perennial cool-season grass, has become dominant across large extents of the northern Great Plains. Due to its rapid invasion and expansion, there is limited information regarding impacts of long-term drought on Kentucky bluegrass invaded plant communities. We report on a 5-year drought experiment established in 2016 near Mandan, ND to determine long-term drought effects on plant community composition in bluegrass invaded rangelands. Drought treatments were designed to intercept 30% and 60% of ambient precipitation using clear plexiglass tiles. We report on results from vegetation measurements taken yearly since 2016 and root biomass measurements taken in 2022. Our results show that drought tends to reduce cover of Kentucky bluegrass and increase cover of native grasses and forbs. At severe drought levels all grasses are affected giving way to forbs. At intermediate drought levels, Kentucky bluegrass was diminished, and some native species became more common. Root biomass at 0-5 and 5-10cm depths differed between drought treatments and control with root biomass decreasing as drought became more severe. However, at the 10-30cm depth there was no significant difference between root biomass of controls and drought treatments, largely attributable to an increase in deeper rooted perennial forbs. Results suggest that prolonged drought in this grassland system can alter the trajectory of invasion of Kentucky bluegrass while affecting both above and belowground productivity.

8

Investigation of Change in Vegetation Attributes at EL_Khauwie District, Western kordofan State, Sudan

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[2]University of East Kordofan, Abū Jubayhah, Sudan

Abstract

This study was conducted at El- khuwei district, West Kordofan State, Sudan; with aims to investigate the vegetation attributes changes at savannah rangelands areas. Methods were used to collection of data using a vegetation measurement measurements studies. The importance results the plant belong to forbs in the botanical composition rather than grasses. The plant species with highest density includes Sida cordifolia and Cassia tora. Plants that had high botanical composition from the ground surveying in the two sites were Sida cordifolia and Cassia tora. Plants that had high frequency were Zarnia glochidiata, and Echinocloa colonum. The study concludes that vegetation alters may be due to climate variability, over grazing and human uses over the time. It is recommended that further investigations should be considered to understand changes in vegetation pattern for design suitable conservation tools of rangeland utilization.

9

Fire Frequency Mapping of Rangeland in South Kordafan State- Sudan an perspective Remote Sensing

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Abstract

The study was conducted in South Kordofan State, Sudan, aiming to determine the fire frequency, seasonal fire and total brunet area in the study area. Moderate Resolution Imaging Spectroradiometer (MODIS) images from fire seasons of 2010 to 2015 were obtained and classified for burnt area in order to investigate the fire frequency for six seasons. ENVI 5.2 and ArcGIS 10.2 software were used for image processing and maps production. The result revealed that the burned areas were high frequency in fire season of 2010-2011 with an area of 316,086.20 hectare. The fire season of 2009-2010 was the next highest one with an area of 312,401.20 hectare. These findings considered as a basis for an informed wildfire management in the study area which will be contribute in forest and rangeland management strategies.

10

Considerations when using remote sensing fractional cover products for land management purposes

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Abstract

Maps of dominant plant cover derived from satellite data are essential for ecological research and management, particularly in the vast semiarid shrub-steppe. Some newer products include Rangeland Analysis Platform (RAP), Rangeland Condition Monitoring Assessment and Projection (RCMAP), and the USGS fractional estimate of exotic annual grass cover, which have been widely used for land management purposes without a clear understanding of limitations and when or where use may or may not be appropriate. Appropriate application of these maps requires an understanding of model accuracy and precision, and how it might vary across space, time, and different vegetation types. Between 2016-2020, we collected plant functional group cover data across a 113 K Ha burned area located along the southern border of Idaho and Oregon. We compared all three fractional cover map products (RAP, RCMAP, and the USGS fractional estimates) to raw field data, as well as interpolated maps created from field data to assess accuracy of different cover types and how map agreement varied across the landscape. All map products tended to over or underestimate cover when field-measured cover was relatively low or high, respectively, i.e. a “false moderating effect”. Accuracy was greater and improved with newer versions of RAP compared to RCMAP and USGS fractional model estimates, and in some cases was greater than field-based models. Variability in map agreement tended to decrease with larger areas sample, and this scale dependency was more evident in RAP and USGS-fractional-EAG models. Map agreement was higher for annual herbaceous and lower for perennial herbaceous cover in lower elevation, flatter areas. Considering landscape heterogeneity, scale, and cover type management goals are all important when deciding how much weight to place on fractional cover map products as a basis for plant community information.

11

Managing Rangelands with Virtual Fencing For Grazing Lands Conservation in Eagle County, Colorado

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Abstract

One solution to facilitating the implementation of flexible and effective grazing rotations on rangelands of the west is to use Virtual Fencing (VF) systems. These systems control livestock herd movements through collars on cattle that receive information on pasture configurations programmed on personal computer devices using GPS technology. The Eagle County Conservation District (ECCD) received a Conservation Innovation Grant from NRCS in 2022 to test VF at rangeland scales. The project's primary goal is to assess how well VF can be applied to manage grazing of cattle on rangelands and as a tool for grazing lands conservation, particularly in a rugged terrain that is characteristic of much of the rangelands of the Western U.S. A network of ten virtual fencing towers was installed in 2021 and is being tested by the Bureau of Land Management (BLM) in the northern Eagle basin area. The ECCD project will add 8 additional towers to this network placed on both private lands and BLM or Forest Service (FS) land, of which 5 have been deployed this year. The towers currently cover several BLM and FS allotments, and privately owned rangeland encompassing over 80,000 acres of rangeland BLM allotments with 90% or better coverage. There are six ranchers participating in the ECCD project with 1750 cattle collared to test the efficacy of the VF system and establish what the limitations are for managing rangelands of the western United States, and how to effectively mitigate topographical constraints. Vegetation sampling was conducted at 48 plots at 15 grazing allotments collecting data on livestock and wildlife use, site productivity, diversity and cover, and infiltration rates. This talk will discuss current accomplishments of the project, as well as insights gained and preliminary exclusion and containment success, and areas being troubleshooted for successful use of the VF system.

12

DUCK, DUCK, COW? HIGH INTESITY, SHORT DURATION WINTER CATTLE GRAZING AS A TOOL FOR WMA WETLAND VEGETATION MANAGEMENT.

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Abstract

Standing, senesced vegetation is a significant issue in wetland habitats on the Sterling Wildlife Management Area, Aberdeen, ID, USA, where the effective use of mowing, burning or other management tools is currently limited. A winter cattle grazing contract was implemented during winter 2021 and 2022, with the purpose of using high-intensity, short duration rotational grazing as a vegetation management tool to improve wetland-marshland habitats in poor-fair condition. The management goal was to break down and remove thick mats of senesced cattails, rushes, grasses, and to open up/promote a more diverse and productive wetland-marshland community for the benefit of waterfowl, upland birds, and other wildlife species. To reduce conflicts with WMA user groups and impacts to wildlife, and to specifically target senesced vegetation, the winter season was chosen as an ideal timeframe. The contract allowed for 400 AUMs maximum; cattle were herded with electrical fencing and moved around a 330 acre segment every 4-7 days, across a total of 6 pastures over 5 weeks in January/February. Lessees were responsible for all cattle management and fence maintenance during this time. Photo points were taken pre- and post-grazing, and following each growing season post-project. Initial results show a reduced amount of standing and dead biomass in the treated segment, increased forage quality, notable changes in new vegetation growth observed from previous seasons with no grazing, and increased selection of treated areas by migrating waterfowl. Additional project benefits included the eliminated winter feed costs for the Lessee, a public/private partnership model being considered on other WMAs in Idaho, and increased community good will and availability of grazing services in the future.

13

Grassland community dynamics are altered within the same growing season following nutrient addition and disturbance

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Abstract

Global change drivers are reducing grassland plant diversity and altering community dynamics. Environmental nutrient influx and disturbance from changing land use practices are two prominent and pervasive drivers of change in grassland systems. We quantified the effect of these mechanisms on grassland community assembly and productivity by setting up an experimental Disturbance and Resources Across Global Grasslands (DRAGNet) site at the Grassland Soil and Water Research Laboratory (GSWRL – Temple, TX USA). The field site consists of 25, 5 m x 5 m plots, arranged in a 5 x 5 Latin square design. Treatments included: (1) Control (C), (2) nitrogen, phosphorus, potassium, and micronutrients addition (NPKµ), (3) disturbance (D), (4) NPKµ + D, and (5) NPKµ cessation (not used in this analysis). The disturbance treatment was carried out in January 2022, while nutrient addition was administered in April 2022. Precent cover surveys were taken monthly in all plots between March – September 2022, and biomass clippings were collected once in June and once in September 2022. Nonparametric multidimensional scaling (NMDS) analysis indicated treatments were significantly dissimilar to each other, and community composition was dependent on treatment type. Total diversity decreased across all treatments relative to the control. Productivity was highest in both nutrient addition treatments (NPKµ and NPKµ+D) but was significantly reduced in the disturbance (D) treatment. Nutrient addition alone resulted in increased cover and productivity in grasses - primarily from an increase in invasive Sorghum halepense cover. Paired nutrient addition and disturbance caused total species turnover and significant reduction in grass and legume cover, but significantly increased the cover and productivity of noxious Ambrosia trifida. Our results indicate grassland plant community dynamics, both cover and productivity, can quickly respond to environmental changes in nutrients and disturbance.

14

Evaluating Ungulate Usage of Rangelands with Black-tailed Prairie Dog Disturbance

Lindsey Buehler[1], David Augustine[2], Lauren Porensky[2], Ana Davidson[3], Courtney Duchardt[1]

[1]Oklahoma State University, Stillwater, OK, USA. [2]USDA-ARS, Fort Collins, CO, USA. [3]Colorado State University, Fort Collins, CO, USA

Abstract

Black-tailed prairie dogs (Cynomys ludovicianus) are considered ecosystem engineers due to their burrows facilitating soil ventilation as well as herbivory and vegetation clipping creating early successional habitat and shifting vegetation composition. Despite the important role prairie dogs play in structuring rangeland ecosystems, conflict with livestock has led to control efforts that have reduced the range of this species. Sylvatic plague (Yersinia pestis) has threatened prairie dog populations for the past century and has further reduced prairie dog populations. This has had detrimental effects on associated species including the endangered black-footed ferrets (Mustela nigripes) and mountain plovers (Charadrius montanus). However, little research has been published on native ungulate species use of prairie dog colonies or their responses to variation in prairie dog disturbance in space or time. In Thunder Basin National Grassland in northeastern Wyoming, we observed a decline in mule deer (Odocoileus hemonius) detection rates via camera trap after a major plague event in the system (0.41 [SE: 0.91] pre-plague to 0.055 [SE: 0.058] post-plague) and decided to investigate this relationship further. In 2022, we deployed camera traps across black-tailed prairie dog range to examine how prairie dogs influence habitat use of different ungulate communities. In two sites, preliminary data indicate greater number of detections on-colony of pronghorn (Antilocapra americana) and bison (Bison bison), respectively, as compared to off-colony habitat. This research represents the first multi-site and multi-season study of the relationship between black-tailed prairie dogs and native ungulates, providing much-needed insight on these ecological relationships at a range-wide scale. Especially on rangelands designated as "multiple use" (e.g., U.S. National Grasslands), the potential benefits of prairie dog presence to ungulate habitat may partially mitigate negative effects on livestock production.

15

Quantifying Encroachment on Rangelands in the Kaibab National Forest

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Abstract

Encroachment has negative effects on rangeland goods and services. Efforts by National Forests to quantify encroachment, especially by Juniperus and Pinus species have been scant. Here we outline the data sources, methods, and results of a recent effort to defining and quantifying encroachment on the Kaibab National Forest. We also discuss a strategy for identifying persistent woodlands and separating these areas from the candidate pool of encroached stands. Data sources include high resolution existing vegetation type, trend of tree canopy cover, soil units, and canopy height derived from airborne Lidar remote sensing. Overall, more than 100,000 acres of encroachment were identified. The primary species involved were Juniperus utahensis and Pinus edulis. Less than 12% of these areas were considered persistent woodland. The high resolution Lidar data combined with a novel approach enable improved management guidelines and can streamline efforts to reduce canopy cover of trees within the encroached areas

16

RE-INTRODUCTION OF PERENNIAL, DROUGHT-RESISTANT FORAGE PASTURE CROPS IN THE CONDITIONS OF THE FOOTHILL ZONE OF UZBEKISTAN

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Abstract

The increase in the areas of degraded pastures, the digression of pastures, the deterioration of biotic communities (ecosystems), the decrease in biodiversity, illegal and haphazard felling of shrubs and trees, haymaking, harvesting of fuel and medicinal herbs have led to the disappearance of many types of forage grasses from the herbage. Within the framework of the UNDP-GEF project "Sustainable use of natural resources and forestry in key mountain regions important for globally significant species of biodiversity", work was carried out to enrich pastures in 2020 - 2022.

The introduction of perennial, highly productive, drought-resistant forage pasture crops was carried out by sowing such species as Kochia prostrata (L) Schrad. and Ceratoides eversmanniana in degraded areas of the foothill zones of Uzbekistan. A site of primary seed production of the Dehkanabad forestry of the Kashkadarya region of Uzbekistan, with an area of 2 hectares, has been created, the seeds of which will be used to increase the productivity of pastures.

In the conditions of 2021, the plants developed well, in the spring of 2022, seeds were planted. The part of the field where a small number of plants were noted, additional seed sowing was carried out. In the conditions of 2022, a good development of pasture species was noted. The height of the plants of izen and teresken reaches 60-95 cm . The projected coverage on the site was 75-80%, the yield was 1.02 tons per hectare.

The creation of plots of drought-resistant perennial forage crops will allow obtaining about 200-240 kg of seeds from 2 hectares in the 3rd year of vegetation and using them in the future to improve the adjacent degraded pasture areas.

Additionally, 2.2 tons of dry mass can be obtained from a 2-hectare plot, which will allow the forestry to have a stable feed base throughout the year.

17

CULTIVATION OF FODDER CROPS BASED ON THE USE OF GROUNDWATER IN THE KYZYLKUM DESERT

Erach Mamtdov

Research Institute of Karakul Sheep Breeding and Ecology of Deserts,, Samarkand, Uzbekistan

Abstract

In strengthening the feed base of karakul breeding, it is important to create a stock of feed for feeding sheep in winter due to irrigated feed production.

Considering that water reserves are limited and in great deficit in the karakul breeding zone, field forage production should be based on the rational use of water resources by cultivating intensive forage crops.

The most promising fodder crops for cultivation on irrigated and conditionally irrigated lands of karakul farms are: alfalfa (varieties “Tashkent”), corn (“Uzbek Zubovidnaya”, “Uzbek 100”), barley (“Unumli arpa”). Cultivation of these crops in conditions of high agricultural technology ensures the production of 7-8 thousand feed units from 1 ha in conditional irrigation areas, 18-20 thousand in normal irrigation areas.

The most rational use of water and land resources is achieved with the widespread use of organic and mineral fertilizers and intermediate fodder crops. The most productive intermediate fodder crop is winter rye and its mixtures with winter vetch, winter rapeseed and fodder peas - One hectare of such a cereal-bean mixture of intermediate crops makes it possible to obtain 8.0-10.0 t/ha of air-dry mass for granulation or 4.0—5.0 thousand fodder units.

18

SELECTION OF BREEDING SOURCES FROM PROMISING SPECIES OF ASTRAGALUS

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Abstract

Astragalus are shrubs, semi—shrubs, perennial and annual herbaceous plants belonging to the legume family (Fabaceae). There are 254 species growing in Uzbekistan. Its composition is rich in proteins, it is well eaten by cattle, and its seeds retain the ability to germinate for 30-40 years.

According to the research results, scarified seeds of the species Astragalus globiceps Bunge, Astragalus alopecias Pall, Astragalus turbinatus Bunge, Astragalus eximins Bunge, Astragalus sieversianus Pall were planted in the initial seed nursery. The variety of astragalus "Oktog" is taken as the standard.

Astragalus began growing from the end of March to the first decade of April and began the budding phase in early May, entered the flowering phase by the end of May, and the seeds ripened in July.

Astragalus are stunted plants, and at the end of the growing season in July, their height was 22.6-37.5 cm. For the third 2022 year of vegetation, the height of plants was 65.5-93.2 cm. The highest height was noted in the spherical astragalus Astragalus globiceps (93.2 cm).

The yield of fodder mass for the first year of the astragalus vegetation by plant species was 0.49-0.73 t/ha of hay. For the third 2022 year of vegetation – 1.32-1.81 t/ha of dry fodder mass. The largest hay yield was recorded in the spherical astragalus Astragalus globiceps (18.1 t/ha). The variety astragalus Oktog, taken as a standard, formed a hay harvest of 1.59 t/ha.

The highest yield of astragalus species is noted from the third year of its vegetation, then from promising astragalus species it is possible to obtain high-quality hay rich in protein and other valuable nutrients for many years, and it is also possible to use these territories as pastures.

19

ORGANIZATION OF SOWING OF PROMISING DESERT-FORAGE PLANT SPECIES

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Abstract

The pastures of desert and hilly areas are used for breeding cattle, camels and goats almost all year round and provide about 95% of the livestock's feed needs.

According to the information, the degradation occurring on 45% of the pastures of our republic requires their effective use, conservation and enrichment of biodiversity, increasing the productivity of pastures, due to phytomelioration.

As a result of the introduction work, promising species were selected, drought-resistant, high-yielding, and resistant to diseases and pests, well eaten by cattle, and their breeding varieties were created.

To create artificial plantings from promising varieties of desert nutrient plants, it is necessary to organize seed-growing areas of these plant species. Because the quality indicators of seeds of plants bred in natural conditions do not fully meet the requirements for creating new highly productive pastures. Seeds prepared from natural pastures (Haloxylon aphyllum) are of poor quality and due to the scattering and rare distribution of plants cause great difficulties in seed preparation.

Row spacing treatment in winter is important for absorbing moisture and destroying weeds in the soil. From the 3rd year of vegetation (5-6 years of Haloxylon aphyllum), plants in established seed-growing areas enter a period of high seed productivity and produce seeds for 20-25 years.

The creation of artificial pastures should be carried out in the form of multicomponent agrophytocenoses (plantings consisting of a mixture of 6-8 plant species). Due to the different periods of vegetation of plants and consumption of plants by livestock, it is possible for cattle to use these fields in all seasons of the year.

The agrophytocenoses created are of great importance in restoring the vegetation cover of pastures, preserving and enriching biodiversity, improving soil cover, increasing productivity 4-5 times, balancing the ecological situation. Also, these plantations produce high yields continuously for 30-40 years.

20

CULTIVATION OF FODDER CROPS BASED ON THE USE OF GROUNDWATER IN THE KYZYLKUM DESERT

Erach Mamedov

Research Institute of Karakul Sheep Breeding and Ecology of Deserts, Samarkand, Uzbekistan

Abstract

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Considering that water reserves are limited and in great deficit in the karakul breeding zone, field forage production should be based on the rational use of water resources by cultivating intensive forage crops.

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Evaluating Changes in Riparian Complex Ecological Sites Over Time

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Abstract

Ecological Site Descriptions (ESDs) are a broadly applicable framework that allow land managers to assess the health and status of ecological systems. The development of ESDs for upland systems relies on the understanding of a different set of ecological processes than for the development of ESDs for riparian systems. This research has been conducted with the intent of providing the necessary data to aid in the development of riparian ESDs. The information collected in this study captures the hydrologic status of 29 stream cross sections across five watersheds in southwestern North Dakota (MLRAs 54, 58D, and 58C) at two points in time, 2016 and 2022. Data was collected in accordance with the Rosgen Stream Classification System. The parameters entrenchment ratio, width-to-depth ratio, bank height ratio, meander width ratio, channel bed material size, and sinuosity were used to classify stream cross sections by channel type (E, C, B, F, and G) and stability class (stable or unstable). Of the 29 cross sections assessed, 14 displayed a change in channel type. There was an increase in E channels from 11 to 14, and a decrease in C and G channels (from 6 to 4 and from 2 to 1 respectively). Three stream reaches were observed which had become channelized since the 2016 assessment when they were identified as event dependent overflow sites. Over time data indicated that entrenchment ratio and bank height ratio increased, while width-to-depth ratio, meander width ratio, and sinuosity decreased. These trends are expected in state and transition models of the Rosgen Stream Classification system and consistent with the formation of state four, stable analog channels. Validating the current models for riparian complexes associated with prairie streams in the Northern Great Plains.

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THE USE OF EFFECTIVE TECHNOLOGIES IN ANIMAL HUSBANDRY IN UZBEKISTAN

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Abstract

Pastoral animal husbandry of the republic is based in regions with low natural resource potential, its technological cycle is mainly extensive and entirely depends on natural and forage conditions. It is multidisciplinary in structure and is located on 23.3 million hectares of land (52%) of which 81.4% are deserts, 11.9 are foothill semi-deserts, 5 are mountainous and 1.9% are high-altitude pastures.

Karakul sheep, goats, camels, horses and other animals (over 10.0 million heads) are kept in the desert pasture region. Sheep breeding is located throughout the territory of the republic and has a breed zoning. The breed of Jaidara sheep is bred in the foothill-plain zones, the Hissar breed of sheep is mainly in the foothill areas, Karakul sheep - in desert regions. Sheep products - meat, milk, wool, pelts, sheepskin.

Karakul farming is localized mainly in the sandy desert (52%), the rest in the sagebrush-ephemeral desert (40.5%) and the foothill semi-desert (8.0%). Specialized karakul farms are concentrated in Karakalpakstan and six regions: Navoi, Kashkadarya, Jizzakh, Samarkand, Bukhara and Surkhandarya regions.

An analysis of the economic and organizational activities of desert-pasture livestock farms and its interaction with the environment revealed the following principles:

- full-fledged, as well as normative feeding and keeping of animals that meet their physiological needs for nutrients and development allow them to fully realize their productive potential;

- rational use of natural and cultivated pastures based on self-renewal of forage plants, increasing the productivity of pastures based on the introduction into culture of highly productive introducers selected from natural flora and varieties bred by breeding, propagated by techniques and methods of seed production allow to provide animals with feed and preserve an ecologically balanced environment

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Plant Community Dynamics, Geomorphology, Hydrology, Carbon Sequestration and Bird Diversity/Abundance through the Lens of a Riparian Ecological Site Description in the northern Great Basin Region

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Abstract

This project is focused on developing a Riparian Complex Ecological Site Description (RCESD), complete with a state and transition model, for low-gradient streams in the northern Great Basin. While upland site descriptions and models are plentiful across the United States, few exist for riparian areas. This work seeks to expand regional coverage and further augment the utility of the model. There is a growing awareness of the importance of riparian systems, especially in arid regions. This increases the need to better understand stream dynamics; anticipate the effects of different disturbances; and to develop specific actions to achieve management goals. The prototype model is being developed on a stream in northern Nevada which is under differing grazing regimes, contains irrigated hay meadows, a grazing exclosure, and has active beaver colonization. Current project efforts are focused on identifying the different states and community phases and where possible, linking them to Rosgen Stream types and different management layers. This format is consistent with the handful of RCESDs in existence. Model augmentation will include a correlation of states/phases to soil carbon sequestration potential. There is increased interest in assessing how disturbances affect carbon cycling on rangelands. Soil organic carbon plays an important role in terrestrial ecosystems and it is hoped that this work will complete some of the ground work necessary to link proactive management to carbon markets without incurring the expense of repeat soil collection/analysis. Additionally, given the vast array of wildlife species that utilize riparian/wetland habitat, there is also interest in including wildlife considerations into riparian-based management and tying them in with easily observable trends. To help fill this void, but simultaneously respecting time constraints, data is also being collected on bird diversity and abundance with the goal of linking population data to specific stable states.

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Improving herbage mass prediction by regression tree analysis

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Abstract

Livestock systems should control grazing intensity at paddock level to control animal productivity. In Campos grassland, grazing intensity can be controlled through herbage allowance (HA). The control of HA relies on data from herbage mass (HM, kg/ha) and stocking rate (kg/ha). Herbage mass estimation is laborious to implement in commercial systems, however the canopy height could be used as a proxy of HM if it could be predicted with accuracy (low error). With the aim to predict the HM based on canopy height we used a data set containing the HM and canopy height of 3270 quadrats, 2616 were used for training and 654 for cross validation. Each of the quadrat was cut at ground level including death and green herbage. Canopy height was measured where herbage become dense, ignoring tall stalks. We used the coefficient (kg/cm) derived from the simple division of HM/height and auxiliary variables were month, accumulated previous month rainfall and the canopy height. We constructed ranges of canopy height, as <3cm, >3<9 cm, >9<15 and >15 cm, and ranges of rainfall were <40, >40<70, >70<130 and >130 mm/month. We used SAS program and Proc HPSPLIT with ftest to grow and cost complexity to prune the trees and then we used the data not used for regression tree for cross validation. Month was the first variable splitting the data into two groups (group 1 = months 10, 12, 1, 2 and 3 group 2 = 4, 5, 6, 7, 8, 9 and 11) previous rainfall and the canopy height significantly affected the coefficient with finally 29 homogeneous groups of HM/height coefficients. Error of prediction by cross validation was between 20 and 30% on average which is lower than previous work with 30% error using linear regression as statistical method.

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Fire reduced Russian olive seed germination and seedling survival with increased fuel load

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Abstract

Elaeagnus angustifolia (Russian olive) is an introduced invasive woody tree that is common within riparian areas in the western United States. Control methods can be expensive and monitoring of removal sites on a regular basis is necessary to control stump and root sprouts and newly established seedlings. Effect of fire on seeds and newly emerged Russian olive seedlings has not been documented. Russian olive seeds were subjected to fire at three fuel loads (1500, 3000, and 4500 kg ha-1) and a non-burned control. With no fire, 40% of seeds germinated on average and fire at any fuel load reduced germination. Germination was reduced to nearly one-fifth of the non-burned level with fire at the 1500 kg ha-1 fuel load and did not differ from 0% at the 4500 kg ha-1 fuel load. The probability of at least 1 seed germinating from the 50-seed lots decreased as all measures of temperature and time-temperature increased. Fire killed all but 1 of the 250 seedlings tested, indicating Russian olive seedlings 10 weeks old or younger were very susceptible to fire-induced mortality. However, some seedlings did not die immediately following fire and produced new axillary buds. Although all but 1 seedling died, bud production after fire was interpreted as an indicator of potential resistance to fire. Our results indicate that fire does not enhance Russian olive seed germination and is deleterious to seed viability. Fire could potentially kill most Russian olive seedlings that are less than one year old.

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Effect of herbage allowance and animal genotype on the selectivity for high and low patches of beef cows grazing native subtropical grassland.

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Abstract

Cow-calf systems are based in native pastures where herbage present a patchy distribution of herbage mass (HM) that have positive covariation with ADF concentration. The patch frequency of high and low HM was the result of changes in seasonal herbage allowance (HA). In this situation of heterogeneity, the selectivity of the cows by sites emerges as a central process in energy consumption, resolved through different mechanisms of ingestion behavior. The aim was to study the selectivity indexes by vegetation patches (HP: high HM patch; LP: low HM patch) of purebred cows (PU: Hereford/Angus) and crosses (CR: F1 AxH) in high and low HA (4 vs 7 kgDM/kgLW). The herbage structure and ingestion behavior were recorded for 3 days, in the 4 seasons on 4 cows per treatment (n=16). The indexes were estimated based on the proportion of patch type in the plot vs bite taken by the cow (Ivlev-Jacob index), which vary from negative to positive values indicating preference or evasion. The effect of HA (high vs low), season (Su, O, W, Sp) and breed (PU vs CR) on the selectivity indexes was analyzed. The indexes varied with the season of the year ($P<0.001$) with a strong avoidance of HP towards summer and autumn (-0.7 y -0.46). However, during winter and spring HP were not avoided (0.03 y -0.13). PU avoided HP in a greater magnitude than CR ($P<0.05$). The LP was preferred throughout the year with greater preference in low HA ($P=0.05$), presenting a strong decrease towards winter and spring when they start to consume the HP. The results indicate that both breeds and HA mainly used the LP, this kind of behavior modified the pretended grazing intensity because HP were assigned but not used by the cows which decreased the HA mainly for the High HA.

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Rangeland Condition Monitoring Assessment and Projection (RCMAP): Tracking Fractional Rangeland Component Cover Over a 36-year Time-series

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Abstract

Rangeland ecosystems are highly variable through space and time, yet most variability manifests as within-state change that is often poorly captured by thematic land cover products. These within-state changes are crucial to understanding climate and management impacts. The Rangeland Condition, Monitoring, Assessment, and Projection (RCMAP) product quantifies the percent cover of rangeland components, associated error, and cover trends across the western U.S. using Landsat imagery. The newest generation of RCMAP provides yearly data for 1985-2021 with an enhanced training data approach, integration of neural network (nn) classifiers, and Continuous Change Detection and Classification (CCDC)-synthetic imagery to better capture phenology. Additionally, the newest generation includes a tree cover component, focusing on pinyon-juniper woodlands. We found that use of nn classifiers improved prediction accuracy and spatial cohesion. Inclusion of 5 months of CCDC-synthetic imagery enhanced our ability to discriminate herbaceous cover from shrub cover and especially annual herbaceous from herbaceous cover. Overall, training accuracy is 48% higher and test accuracy is 36% higher than the prior version of RCMAP. A new generation of trends analysis metrics has been derived for each component using a structural change model, typically applied to raw spectral values from satellite imagery, but in our case, to find break points in the time-series of cover values. We will continue to advance RCMAP product accuracy with investigations of convolutional neural network classifiers and introduction of training data with spatial and temporal offsets to leverage spatial and temporal autocorrelation. We have enhanced the MRLC rangelands viewer (https://www.mrlc.gov/rangeland-viewer/) by enabling time-series plotting of component cover by pasture, allotment, watershed, etc. RCMAP data download and services are available at www.mrlc.gov. Datasets provide spatially, temporally, and thematically detailed information on rangeland condition change and attribute change events to specific component(s).

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Mapping Grassland Plant Communities Subjected to Nutrient Influx and Disturbance using UAV Remote Sensing and Machine Learning

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Abstract

Nutrient influx and disturbance are among the most pervasive and severe drivers of global change in grassland plant communities. Future sustainability relies on detecting and understanding changes in these ecosystems. The emergence of unmanned aerial vehicle (UAV) remote sensing technology as a tool to efficiently collect data over large spatial scales suggests its use as a technique to assess changes in grassland community composition. We evaluated multispectral imagery on 25 grassland communities during the 2022 growing season (March – September). Each community was designated as a control plot (C) or a plot subject to nutrient influx (NPKµ), disturbance (D), or nutrient influx + disturbance (NPKµ+D). We compiled three datasets from five spectral bands and 13 calculated vegetation indices: (1) spectral bands only (B), (2) vegetation indices only (I), and (3) spectral bands + vegetation indices (B+I). Community composition from each dataset was classified using a supervised classification method based on a Random Forest classifier. Classification accuracies were dependent on both the dataset (B, I, B+I) and date. Classification accuracy was best for all three datasets between May – July. This range of months coincided with peak productivity and peak phenological differences between plant functional groups. Classification accuracies for all three datasets were lowering during early growing season months (March and April), as well as late growing season months (August and September). This can likely be explained by difficulties in detecting phenological diversity between plant functional groups during the early growing season and difficulties in detecting differences between living and senesced plant matter during the late growing season while training the Random Forest. The results from our study indicate that UAV multispectral imagery is indeed sufficient at assessing grassland communities subjected to nutrient influx and disturbance, however, attention is warranted when considering timing of image acquisition.

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What Drives Cattle to Water? Accounting for Summer Riparian Use to Inform Management

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Abstract

Sustainable grazing by livestock in riparian pastures, especially those supporting ESA-listed fish or other sensitive species, requires strategic management to minimize the time spent by cattle in streams and adjacent riparian corridors. Although numerous habitat selection models have been developed to predict cattle distributions in landscapes with and without riparian areas, identification of specific temporal factors that most strongly influence cattle use of the riparian corridor is lacking. Moreover, integration of active herding of cattle with abiotic factors such as weather, and the relative impact of each in predicting cattle occupancy of riparian areas, has not been reported in the literature. To better understand these interactions, we investigated the roles of season, weather, and herding in predicting the daily proportion of cattle locations in the riparian area during summer (~June – September). Our analyses were based on telemetry location data from ~20-25 collared cattle collected during 4 years of a grazing experiment along Meadow Creek in the Starkey Experimental Forest and Range in northeastern Oregon, USA. We used a hierarchical modeling approach with beta regression to select the top covariates from modeling groups (e.g., precipitation, herding), fit all possible models (n=307), and selected the best model based on information-theoretic methods. We found that cattle use of the riparian zone increased with greater Julian date, measures of solar radiation, temperature, humidity, and days since herding. Application of the model could help grazing managers predict whether disproportionate or non-sustainable use of the riparian area by cattle is likely to occur given predicted weather, season of use, and implementation of strategic herding to reduce riparian use and associated effects.

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Statistical survey designs, models, and management: Bridging the gap for practitioners in sagebrush steppe

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Abstract

Why bother with statistics? As land managers and practicing conservationists working in the trenches, how often do we pause and reflect on this question? More generally, why does it continue to be so difficult to connect the dots from emerging scientific discoveries and best practices to on-the-ground management decisions. How can we better translate science into action? I don't presume to have solid answers to these questions but rather develop a suite of insights based on my 20 years of experience working alongside statisticians and land managers in sagebrush country. In fact, there are multiple exciting examples of successful gap bridging across the rangeland management arena, such as the rapid uptake and practical applications of resilience and resistance concepts, the findings from the SageSTEP treatment evaluation program, and from within my own National Park Service's Vital Signs Monitoring Program. New statistical approaches and tools, including those discussed within this special session, can play an important role in catalyzing action because they provide practical flexibility to rigorous survey designs and downstream analyses and offer more realistic and compelling models of the complex realities we try to understand and manage. Statistics and the ecological sciences, generally, offer increasingly important tools for us as we grapple with huge data and rapid and uncertain changes at very broad multi-jurisdictional scales. As practitioners, we need these tools to fulfill our adaptive management aspirations to "learn by doing", to protect ourselves against mistakes born from confirmation bias, and to break free from the paralysis of indecision with confidence to try out new (and old) ideas. There is an urgency to this conversation because of the rapid rates of ecological transformation underway, and the time required to develop, implement, and evaluate our activities, update our best practices, rinse, and repeat this learning process.

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Detecting the Invasion of Old World Bluestem (*Bothriochloa* spp.) in Kansas Grasslands via PlanetScope and Sentinel-2 Satellite Imagery

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Abstract

Old World Bluestem (OWB), *Bothriochloa* spp., are perennial warm-season grasses that have invaded vast regions of Kansas, Texas, and Oklahoma due to their grazing tolerance (1). These introduced grasses decrease range ecosystem health due to their growth habits and unpalatableness for cattle (1). Therefore, efficient detection and management of OWB is crucial. The use of remote sensing technology to track invasive species is one method that may save resources. Historically, remote sensing has not been used for detecting OWB due to its spectral similarities to native grasses. The purpose of this project was to develop an effective algorithm for detecting OWB via multispectral imagery. Two study sites of OWB invasion in Kansas were utilized. Two different spatial resolutions of imagery were used—Sentinel-2 (10-meter resolution) and PlanetScope (3-meter resolution). Imagery data were selected from April-October of 2020 to analyze the spectral characteristics of OWB and surrounding land cover types temporally. Both NDVI and true-color composites of imagery were analyzed. Data were classified via an unsupervised IsoData method in ENVI. Initial results have revealed that higher spatial resolution PlanetScope imagery performs better in discerning OWB. Preliminarily, true-color imagery may perform better than NDVI imagery. The current results are promising, but ground truth data is needed to determine whether OWB-classified areas outside of the two confirmed study sites are OWB or spectrally similar for other reasons. The next steps in this project involve supervised classification, cluster-busting of initial classes, and further ground truthing.

(1). Harmoney, K.R. et. al (2007). Suppression of Caucasian Old World Bluestem with Split Application of Herbicides. Weed Technology, 21(3), 573-577.

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Prospects for grazing management to AMP up soil carbon on California rangelands

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Abstract

Despite a lack of research, grazing management is thought to be an ineffective soil organic carbon (SOC) sequestration strategy on rangelands. Semi-arid rangelands in California account for the majority of the state's land mass, and have lost a significant amount of SOC due to annual grass invasion, historical overgrazing, and cultivation. Adaptive multi-paddock (AMP) grazing is a grazing management strategy gaining popular attention because of the large SOC changes measured in temperate and sub-humid grasslands, but little work has been done to understand its efficacy on semi-arid rangelands, which account for the majority of grazing lands globally. To understand the impact of AMP grazing versus conventional (CONV), or low-rotational, grazing on semi-arid California rangeland SOC stocks, we collected 1440 soil samples at four paired AMP/CONV sites across northern California. We measured differences in SOC down to 100cm, SOC stabilization in four soil organic matter fractions (dissolved [DOM], free [fPOM] and occluded [oPOM] particulate, and mineral associated [MAOM] organic matter) in surface soils (0-10cm and 10-30cm), and plant community composition. Three of the four AMP grazed ranches contained significantly greater SOC stocks in surface soils (0-10cm), and two contained greater SOC stocks down to 100cm. The majority of these SOC differences between AMP and CONV ranches were in the MAOM fraction, which is the most persistent form of SOC, with implications for climate change mitigation. Plant community composition varied by site – some AMP grazed ranches had greater composition of perennial vs annual grasses and overall less bare ground, but these findings were not universal. This study is the first look into AMP grazing management on SOC outcomes in California rangelands. Our findings suggest that AMP grazing may be a viable SOC sequestration strategy on semi-arid rangelands, though further research is needed to assess site specific constraints and driving mechanisms.

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Ten-year ecological responses to fuel treatments within semiarid Wyoming big sagebrush ecosystems

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Abstract

Sagebrush ecosystems of western North America are threatened by invasive annual grasses and wildfires that can remove fire-intolerant shrubs for decades. Fuel reduction treatments are used to aid in fire suppression, conserve wildlife habitat, and restore historical fire regimes, but long-term ecological impacts of these treatments are not clear. In 2006, we initiated fuel reduction treatments (prescribed fire, mowing, and herbicide applications [tebuthiuron and imazapic]) in six Artemisia tridentata ssp. wyomingensis communities. We evaluated long-term effects of these fuel treatments on: (1) magnitude and longevity of fuel reduction; (2) Greater Sage-grouse habitat characteristics; and (3) ecological resilience and resistance to invasive annual grasses. Responses were analyzed using repeated-measures linear mixed models. Prescribed fire produced the greatest reduction in woody fuel. Mowing initially reduced woody biomass, which recovered by year 10. Tebuthiuron did not significantly reduce woody biomass compared to controls. All woody fuel treatments reduced sagebrush cover to below 15% (recommended minimum for Greater Sage-grouse habitat), but only prescribed fire reduced cover to below controls. Median mowed sagebrush height remained above the recommended 30 cm. Ecological resilience to woody fuel treatments was lowest with fire and greatest with mowing. Low resilience over the 10 posttreatment years was identified by: (1) poor perennial plant recovery posttreatment with sustained reductions in cover and density of some perennial plant species; (2) sustained reductions in lichen and moss cover; and (3) increases in cheatgrass cover. Although 10 years is insufficient to conclusively describe final ecological responses to fuel treatments, mowing woody fuels has the greatest potential to reduce woody fuel, minimize shrub mortality and soil disturbance, maintain lichens and mosses, and minimize long-term negative impacts on Greater Sage-grouse habitat. However, maintaining ecological resilience and resistance to invasion may be threatened by increases in cheatgrass cover.

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Development of a Rhizobium Seed Coating to Establish Lupine Species on Reclaimed Minelands

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Abstract

The establishment of native plant species on degraded and altered landscapes can be a widespread problem. A contributing factor to the success of a plant's survival may be symbiotic partners that inhabit the plant rhizosphere. These symbiotic partners may aid in nutrient acquisition, pathogen protection, stress tolerance, and many other things. Unfortunately, symbiotic microbes often have little to no presence in altered landscapes, so they must be re-integrated into the area to increase establishment and survival. We evaluated within a laboratory setting the ability of commercial and indigenous rhizobia strains to form nodules on lupine species used for rangeland seedings in the Great Basin region of the western United States and ascertained if these strains could be applied through a seed coating. We also evaluated if a compost amendment applied via seed coating could further enhance the performance of the rhizobia strains. Analysis showed successful nodulation could occur using commercial and wildland-collected indigenous strains through either a liquid culture applied to seedlings or as a dry seed coating. However, the number of root nodules and the presence of a pink color (indicating nitrogen fixation) were typically higher in the commercial product than in the indigenous strains. Compost did not improve nodulation or the performance of the nodules; however, this treatment alone improved shoot growth. Longer-term studies are now merited for assessing how the rhizobia strains evaluated in this study influence plant growth, particularly in a field setting.

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Gradient Analysis and Classification of Tall Forb Communities in the Bridger Teton National Forest, USA.

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Abstract

Tall forb plant mixed upland-herb communities are exemplified by high plant diversity and a profusion of luxuriant wildflowers throughout subalpine mountain parklands of the interior western United States. Twenty three sites from three subalpine areas representing historic plant community status in the Bridger Teton National Forest were identified and selected for analysis after a sustained cessation of grazing activities. The study purpose was to explore and characterize potential ecological sites within this type and respective rangeland health and condition for those sites, which are central to guiding monitoring and applying conservation measures. Seven tall forb cluster groups were identified with specific correlated environmental gradients such as elevation, average annual precipitation, surficial geology, three-dimensional geomorphic descriptions, soil clay content, foliar and ground cover, and diversity dynamics. On the sample sites, we identified 31 families, 112 genera, and 158 plant species (61 species representing native indicator reference species and 97 native secondary species). Beta diversity and plant species turnover between the seven cluster groups ranged from 6.7 to 41.9% indicating discrete differences in plant species assemblages and site dynamics. None of the seven identified tall forb cluster groups met criterion for proper functioning condition as suggested in the historical literature and current technical note guidelines. The seven tall forb clusters are characteristic of specific and unique plant species composition, species diversity, and environmental factors. Developing an overarching set of parameters for determining rangeland health and condition for the identified tall forb community clusters is not possible given the distinctive characteristics associated with each cluster identified in this study. Criteria for conservation management (watershed dynamics, and livestock and wildlife grazing) and monitoring will require specific consideration of environmental factors (foliar and ground cover, litter) and key dominant native indicator reference species and native secondary species composition for each identified tall forb ecological site.

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Rehabilitating Extremely Arid Habitats

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Abstract

It is well documented how difficult of a task resource managers have when attempting to restore or rehabilitate disturbed or degraded habitats throughout the Great Basin. These challenges are multiplied many times over when attempting to restore or rehabilitate severely arid habitats. Researchers have reported that favorable conditions to establish seeded plants in these arid environments may only occur 1 out of every 4 years, while others have reported the necessary conditions needed to recruit natural or artificially induced seedling recruitment vegetation may only occur 1 or 2 years out of every 15 years. Nonetheless, many of these habitats are critical to wildlife as well as sustainable grazing practices. We tested the use of pre-emergent herbicides Imazapic and Sulfometuron Methyl in a replicated complete block design in degraded winterfat/Indian ricegrass/galleta grass community in eastern Nevada from 2015-2020. Herbicide treated plots were fallowed for 1-year and then seeded the following October with a no-till drill (2017 and 2018). The site averages less than 178 mm of annual precipitation, while during this study the site received as little as 122 mm in 2020 and as much as 264 mm in 2019. Each herbicide treated plot was seeded with a Native, Introduced and Native/introduced seed mix. Plots seeded in 2017 were significantly higher in the Introduced and Native/Introduced seed mix with a high of 27 plants/m^2 in the Introduced plot and a low of 9 plants/m^2 in the native mix plot. There was no significant difference in herbicide treated plots. Seeded control plots averaged 8 plants/m^2 while unseeded control plots averaged 1.4 plants.m^2. Aggressive weed control practices and proper plant materials can significantly increase grazing and wildlife resources as experienced in the nearly 600% increase in seeded perennial grasses in this study.

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Perennial Grass Emergence Following Indaziflam and Imazapic Applications on Great Basin Rangelands

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Abstract

Exotic and invasive annual grasses, such as cheatgrass (Bromus tectorum) continue to provide an early maturing fine-textured fuel that increases the chance, rate, spread and season of wildfires throughout the Intermountain West. Resource managers and land owners require viable tools to combat this ongoing challenge in an effort to reduce wildfire threats and improve grazing and wildlife resources. Chemical applications of soil-active pre-emergent herbicides has increased in popularity as well as applications on Great Basin rangelands. We tested the more widely used herbicide, Imazapic, to the recently introduced herbicide, Indaziflam on cheatgrass control and perennial grass seedling mergence. Due to reporting that Indaziflam is known to have a longer soil activity than Imazapic, we tested the seeding of perennial grasses on plots that were fallowed for 1, 2 and 3-years at our TS Ranch study site in northern Nevada. Cheatgrass control with Indaziflam ranged from 84.8 – 98.6%, while cheatgrass control with Imazapic ranged from 94.2 - 97.8%. Following the prescribed fallows on each plot, Native, Introduced and Native/Introduced perennial grass seed mixes were seeded using a no-till drill in October of the prescribed fallow period. Imazapic treated plots recorded the highest perennial grass emergence in the 3-year fallow, 109/m² in the Introduced seed mix while the highest recorded perennial grass density in the Indaziflam plots were recorded in the 2-year fallow, 32/m² in the Introduced seed mix. Native seed mix plots recorded the lowest perennial grass emergence, such as 2/m² in the Indaziflam 1-year fallow plots. The extended herbicide residue of Indaziflam appears to limit seedling emergence of perennial grasses in restoration and rehabilitation efforts, therefor resource managers and land owners should be aware of this residue activity and the extended time needed to recruit perennial grasses following cheatgrass control efforts with Indaziflam.

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Trait responses of a grassland shrub invader to altered moisture regimes

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Abstract

Shrubs are typically highly persistent after their establishment. Accordingly, an understanding of the factors governing their early establishment is foundational. We sought to identify plant traits important for the initial establishment of a globally invasive shrub, *Prosopis* spp. (mesquite), by quantifying morphological and ecophysiological responses of seedlings to contrasting moisture regimes. Our model plant was *Prosopis velutina* (velvet mesquite), a prominent invader of grasslands of the Sonoran Desert. Using a controlled, greenhouse environment, seedlings received one of three watering levels corresponding to Sonoran Desert regional ‘ambient’ (100%), ‘dry’ (-65%; 65% of ambient), and ‘wet’ (+165%; 65% above ambient) growing season precipitation regimes. A total of 32 performance (e.g., biomass and growth) and functional (e.g., morphological and physiological) traits were assessed when seedlings reached 11- and 22-days old. Germination under dry conditions was quite high (72%) and only marginally reduced compared to ambient (97%) and wet (97%) conditions with subsequent seedling survival unaffected. Wide trait adaptability enabled early recruitment over the entire range of soil moisture conditions, including extreme drought. Root functional traits (volume, surface area, tips, tap root length), and leaf length were the top predictors of seedling performance; fresh weight, absolute growth rate, and root mass were secondary contributors. Physiological functional traits were neither significant predictors of performance nor in discriminating between moisture regimes, suggesting morphological traits for maintaining metabolic and hydraulic function are key to early establishment. Germination and early establishment readily occurred in moisture regimes mimicking average and well below-average rainfall, suggesting recruitment of certain rangeland shrubs may not be episodic with respect to rainfall. Wide-ranging performance and functional trait adaptability in response to available soil moisture helps explain why *Prosopis* spp. have so readily established on global rangelands in past decades while the many other shrub species in the regional flora have not.

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Restoration of meadow ecosystem processes through grazing management increased carbon storage.

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Abstract

Soils in semiarid riparian ecosystems have large carbon stocks that promote water and nutrient availability for productive plant communities consumed by grazing animals. Changes to riparian hydrologic conditions caused by channel incision result in different edaphic conditions and a greater abundance of less productive upland plant species that may be associated with lower soil carbon stocks. Can grazing management alone change riparian hydrologic conditions and increase soil carbon stocks? Using riparian meadows alongside Maggie Creek in central Nevada, we show that 27 years of modified grazing practices can start to reverse the negative impacts of channel incision on carbon stocks. We compared carbon stocks (of soils and plant biomass) on floodplains, terraces, and uplands of reaches where grazing was either modified or excluded to reaches where no changes to grazing practices were made. Roughly 80% of gains in ecosystem carbon were due to increased soil carbon. Grazing management allowed beaver to establish, resulting in proportional gains in ecosystem carbon and nitrogen on geomorphic surfaces extending from the stream channel to the edge of the hillslopes surrounding Maggie Creek. Gains in ecosystem carbon ranged from 93-452 g C m^{-2} y^{-1}, which is comparable to gains found in restored wetlands and meadows located in more humid ecosystems. Carbon gains exhibited substantial variability caused by microtopography, plant community composition, and subsurface processes. While grazing exclusion resulted in the largest gains in ecosystem carbon, managed grazing increased ecosystem carbon relative to reaches where management wasn't changed. Our results demonstrate that managed grazing can be compatible with projects aimed at increasing soil carbon in semiarid riparian rangelands.

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Weather drivers of Wyoming big sagebrush steppe production dynamics across plant associations

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Abstract

High interannual variability in production occurs in many semi-arid rangelands, including the perennial dominated sagebrush steppe, in response to variable weather conditions. Describing the effects of weather on the dynamics of sagebrush steppe has implications for a broad set of management objectives including forage and habitat for sensitive species, such as greater sage grouse. We investigated the effects of seasonal weather and plant associations, related to abiotic characteristics, on herbaceous production dynamics across 44 intact, representative Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*) steppe sites across eastern Oregon from 2003-2012. We tested for the effects of sampling year, lagged precipitation, and potential evapotranspiration predictors, prior year biomass, and plant association herbaceous functional group production. We also tested for synchrony across functional groups and plant associations. We found that spring precipitation was the most consistent predictor of production, however, several other variables including prior year weather significantly affected production. Production sensitivity to weather was combined with high synchrony across functional groups and associations, suggesting low potential for production stability associated with asynchrony in northern Great Basin sagebrush steppe.

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Effects of Fire Seasonality and Frequency on the Phytochemical Properties of Resprouting Shrub Species in West Texas

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Abstract

Targeted livestock grazing can complement prescribed fire and effectively reduce the canopy cover of woody plants. As browsers, goats can favorably manipulate woody vegetation by reducing fine fuel loads and suppressing the growth of resprouts. The success of this strategy, however, is contingent upon the selection or avoidance of target plant species by goats. Plant stress acclimation responses may alter the accumulation of plant secondary compounds and directly influence herbivory. Further, antiherbivore plant defense mechanisms promote the survivability of the plant which can indirectly affect grazing by influencing long-term changes in vegetation density and distribution in favor of unpalatable plant species. A broader understanding of how resprouting shrub species and their associated plant secondary compounds respond to the variation in seasonality and frequency of prescribed fire can be used to the advantage of the rangeland manager by facilitating educated decision-making. If plants become less chemically defended, the opportunity may exist to capitalize on the increased herbivory of an underutilized forage species. Conversely, timing and intensity of fire could be tools used to lessen the negative impact of plants that become more chemically defended following fire. Although we cannot control all variables on the landscape that drive change, we can seek to enhance our knowledge of how individual parts respond to these drivers so we may build upon the resiliency of rangelands and alter management strategies accordingly. The objectives of this study are to 1) determine if the season of fire (spring, summer, or fall) influences the accumulation of plant secondary metabolites in honey mesquite (*Prosopis glandulosa* Torr.), lotebush (*Ziziphus obtusifolia*), and algerita (*Mahonia trifoliolata*) during the resprouting process, 2) to analyze the influence of disturbance (e.g., fire, repeated fire, grazing) on the concentration and composition of monoterpenes in redberry juniper (*Juniperus pinchotii*) foliage.

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Chlorophyll fluorescence of fourwing saltbush (*Atriplex canescens*) and blue dalea (*Dalea bicolor*) under climate change scenarios

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Abstract

Experts from the Intergovernmental Panel on Climate Change (IPCC) have projected increments in the concentration of greenhouse gases in the atmosphere, including carbon dioxide (CO2), which will cause increases in the ambient temperature and changes in the precipitation patterns of arid and semiarid regions of the planet, among other effects. If these projections become a reality, the physiological capacity of some plant species may get altered. In the Chihuahuan Desert, fourwing saltbush (Atriplex canescens) and blue dalea (Dalea bicolor) are native shrubs species, which are important for cattle consumption due to their high nutritional value and wide presence; however, their physiological capacity to grow under the aforementioned projected environmental conditions and to continue being a good forage source is unknown. This study analyzed the physiological responses, by means of chlorophyll fluorescence, particularly the photosynthetic efficiency (PSII), of plants of blue dalea and fourwing saltbush exposed to two environments with elevated concentrations of CO2 (737.74±82.65 and 1250.30±177.45 µmol mol-1), representing conditions projected by the IPCC. The PSII under ambient CO2 concentrations (406.50±54.85 µmol mol-1) were tested as a control. Measurements were performed on a weekly basis during four weeks. On each measurement day, data of PSII were registered at four measurement times: night, morning, noon, and evening. The increment of CO2 in the evaluated environments did not affect the global physiological responses of the species evaluated. However, the comparative performance significantly varied between the two species, where blue dalea consistently showed higher PSII than fourwing saltbush (P<0.0001). In addition, PSII also varied among the days and among the measurement times evaluated (P<0.0001) based on the CO2 concentration in the atmosphere.

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Exploring effective detection of Prickly Pear Cactus (Opuntia lindheimerii) from airborne imagery before and after prescribed fires in the Edwards Plateau

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Abstract

Prickly pear cactus (*Opuntia lindheimerii*) encroachment has significantly increased on rangelands in Texas and other semi-arid areas over the past century. However, mapping the extent of encroachment is lacking. Several remote sensing methods exist for high-resolution image classification, including machine learning (ML) techniques such as Random Forest (RF) and Support Vector Machines (SVM). In this study, we explore the performance of ML classification for accurately mapping prickly pear cactus within heterogeneous savannas from multispectral airborne imagery. Airborne multispectral (0.22-m resolution) imagery was acquired before and after patch burning on a research ranch in the Edwards Plateau of Texas for use in ML classification. For training and testing the ML classification, prickly pear cover data were collected from 188 (2-m) radius plots within a 171-acre burn unit, both prefire and post-fire.

After classification, we evaluated accuracy performance for classifying prickly pear for pre- and post-fire imagery. An analysis of pre and post-fire plot data indicated that prickly pear cover declined significantly after the burn (p-value = 0.016), while significant reductions in herbaceous canopy structure within (p-value = 0.02). Results showed that the SVM model slightly outperformed the RF model by scoring a higher Kappa (0.79 vs. 0.77), Accuracy (0.83 vs. 0.81), and a higher prickly pear detection rate in prefire (0.38 vs. 0.19) and postfire (0.68 vs.0.42) imagery. The overall (%) change in classified prickly pear cover in the burn unit showed a 10.5% decline after the burn, with an increase of 6.4% of cover in unburned areas within the burn unit. After the burn, prickly pear continued to decline by 10.6% within the burn areas while increasing by 7.0% in unburned areas. Given the lower-than-expected detection of prickly pear, future work will focus on adding spectral index bands (e.g., NDVI and NDWI), DSM, and texture bands to improve classification performance.

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Publication of the New USDA-NRCS National Range and Pasture Handbook

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Abstract

The National Range and Pasture Handbook (NRPH) provides the USDA Natural Resources Conservation Service (NRCS) with technical information, methodologies, and procedures for assisting land managers, farmers, ranchers, organizations, governmental units, and soil and water conservation districts in planning and applying conservation on non-Federal grazing lands across the United States. The NRPH was developed by NRCS grazing lands specialists with collaboration from the Agriculture Research Service, Bureau of Land Management, U.S. Forest Service, land grant universities, State agencies, consultants, and researchers to provide advancement of technology on grazing lands and the grazing discipline. The new handbook has been entirely rewritten including subparts on Grazingland Resources, Ecological Sites and use in Conservation Planning and Monitoring, Resource Concerns and NRI analyses, Conservation Planning, Inventory Assessment and Monitoring, Management of Grazinglands, Rangeland Ecohydrology, Livestock Nutrition and Husbandry, Wildlife Management, Prescribed Burning, An Ecosystem View of Range and Pasture Soil Health, Grazingland Economics, and Pollinator Habitat. The new handbook includes scientific citations in the text and references are provided at the end of each subpart, showing the cited literature. This improves transparency on sources of information, credits, and attributes original authors and creators. The references also increase accessibility of finding additional information, document the advancement of research, and build integrity and trust in the information provided in this handbook as a national document for NRCS staff working on grazing lands. This document is available as a free download from the NRCS's eDirectives Electronic Directives System.

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An Innovative Approach to Controlling Medusahead at a Management Scale

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Abstract

Medusahead (*Taeniatherum caput-medusae*) is a problematic invader throughout the western United States. Medusahead outcompetes native vegetation and therefore reduces plant diversity. The species also alters fire regimes and can cause large scale wildfires, leading to the loss of intact sagebrush (*Artemisia* spp.) steppe. Previous research has shown that it can be successfully controlled and revegetated with native vegetation utilizing prescribed fire followed by fall application of imazapic, a pre-emergent herbicide. Indaziflam, another pre-emergent herbicide, has also shown promise in controlling medusahead. Most trials to date with these herbicides have not been conducted at a scale relevant to management. Therefore, we developed a study to (1) test the applicability of combining prescribed fire, pre-emergent herbicide application, and re-seeding at achieving control of medusahead and revegetation of desirable species at a management scale, and (2) to compare the efficiency of indaziflam and imazapic within these treatment combinations. Our design involved 4 split plots treated with fire and herbicide (split = type of herbicide) and two untreated control plots. Prescribed fire followed by application of both herbicides occurred in October 2020. In November 2021, we no-till drilled a perennial grass and sagebrush seed mix. Frequency and canopy coverage at the species level was collected yearly each summer using 1 X 1 m frames at 30 points in each split plot. While after one growing season, we saw noticeable control of medusahead, particularly in the imazapic treatments, medusahead frequency and canopy cover increased after two growing seasons. After two growing seasons following herbicide application, medusahead canopy coverage was 15% in imazapic plots, 27% at plots treated with indaziflam, and 61% in control plots. Frequency of sampling points with medusahead presence was similar between the herbicide types (81-83%). We will continue to monitor these plots to determine seeding success.

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Detecting Spatiotemporal Variation of Alfalfa Leaf Area with Drone

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Abstract

Variable Rate Irrigation (VRI) is a management approach that conserves water by managing irrigations for site-specific management zones within an irrigated field. Alfalfa (Medicago sativa) is a crop that demands high irrigation rates in semi-arid regions of the world, making it an ideal crop for VRI. VRI is improved when crop canopy height is known and used as function of crop coefficient, which can then be clustered into zones. The objective of this study is to use drone imagery to estimate spatiotemporal changes in leaf area of an alfalfa field under center-pivot sprinkler irrigation. The 22.7 hectare alfalfa field is located in Rexburg, ID, USA elevation 1518m. The annual precipitation is 339mm with the majority coming in the winter as snow. The soil is a shallow silt loam. There were 11 drone flight missions using a DJI Phantom 4 at 150m above ground equipped with RGB and NIR cameras across the growing season. Manually measured leaf area index with a ceptometer were compared to vegetation indices from the drone imagery. There is a difference in mean plant leaf area index temporally as the crop grows ($p < 0.05$). We can see a difference in plant leaf area index spatially across the field during each of the flights ($p < 0.05$). The spatial variation in leaf area can be used as a function to better represent crop coefficient and create management zones. Farmers can use drones to be more efficient, implement VRI, and make management decisions.

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Adaptive, multi-paddock, rotational grazing management alters foraging behavior and spatial grazing distribution of free-ranging cattle

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Abstract

Sustainable management of grazinglands depends upon understanding how management practices influence livestock movements in space and time. We conducted a ranch-scale (2,600-ha) social-ecological experiment to examine how foraging behavior of cattle differs between a single large herd rotated adaptively among paddocks (collaborative, adaptive rangeland management; CARM) versus continuous, season-long grazing of paddocks by small non-rotational herds (traditional rangeland management; TRM). We analyzed how differences in cattle movement patterns may be linked to reductions in cattle growth rates and diet quality in the CARM treatment, relative to TRM. Cattle in the CARM treatment exhibited more linear grazing pathways, moved at lower velocity while grazing, and exhibited longer grazing bouts early in the growing season compared to TRM cattle. Grazing time within any given 10 x 10 m area was distributed more unevenly across TRM vs. CARM paddocks in years with average or above-average precipitation, but not in dry years. In all years, areas of high and low grazing intensity were more spatially clustered in TRM than CARM paddocks. Movement patterns of cattle managed using adaptive, multi-paddock rotations at high stock density (CARM) are consistent with less selective foraging. Such cattle form a “grazing front” that moves across the paddock and distributes grazing pressure in a more spatially homogeneous fashion. In years with substantial forage production, TRM cattle spent more time than CARM cattle in preferred areas of the paddock and foraged in more circular patches. In dry years, however, both treatments resulted in similarly even grazing distribution, likely due to limited intra-paddock variation in forage quality and quantity. At the ranch scale, these different intra-paddock movement patterns led to reductions in animal growth rates and no overall effect of grazing management on forage production.

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Disturbance, Drought and Nutrients: Investigating Absinthe Invasion in Native Grassland in the Canadian Prairies

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Abstract

The success of invasive plants can be related to available resources, disturbance and the resident plant community, although the factors affecting initial survival may be different than those affecting long-term success. Nutrient addition can limit initial invasion by stimulating competition, but may favour invaders in the long term by promoting their growth. Disturbance, conversely, is likely to increase initial invasion and may facilitate growth by reducing competition, provided that no additional disturbance occurs. Combined, nutrients and disturbance may maximize invader success by increasing resources and lowering competition. The health of the plant community is also important, as diverse pastures can better exclude invaders, while previously invaded pastures may be more vulnerable.

We studied absinthe (Artemisia absinthium) invasion in a native grassland near Saskatoon, Canada. In summer 2021, we applied herbicide and fertilizer to 10 blocks split between a recent prescribed fire and a neighbouring unburnt area (40 plots). Two absinthe seedlings were transplanted into each plot in 2021 and 2022. We monitored their survival and harvested one per pair in the year that they were transplanted. Extreme drought occurred in 2021, while 2022 was relatively normal.

In the initial year, absinthe survival was high, despite the drought. Survival was reduced by 50% in undisturbed-fertilized plots, however, suggesting fertilizer initially increased competition. Overwinter survival was dramatically different, with 85% survival in herbicide-treated plots and no survival in unsprayed plots. In the wetter second year, survival was again high in herbicide-treated plots, but orders of magnitude lower in undisturbed and burned vegetation, especially when fertilized. Combined, this suggests that drought stress may increase initial invasion, but that disturbance is required for long-term survival. These results highlight the risk of absinthe invasion associated with intensive disturbance of rangelands, especially during drought.

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Western Juniper Ecohydrology

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Abstract

The results from a long-term study in western juniper (*Juniperus occidentalis*) dominated settings of central Oregon showed greater soil moisture levels and an increase in shallow groundwater residence time in the watershed where 90% of juniper was removed in 2005. Comparative findings regarding evapotranspiration (ET) from a field data-based water budget, a physically based model, and various remote sensing-based models showed ET is the most significant water output (>80%) in treated and untreated areas. Measurements of juniper tree transpiration showed water uptake was variable, averaging 45 L day^{-1} during the summer in a dry year vs. 88 L day^{-1} in a wet year. Springflow and streamflow rates were generally higher at the treated watershed. This was particularly evident in snow-dominated precipitation years when greater amounts of groundwater recharge and deep percolation were also observed. Juniper canopy intercepted a significant amount of rainfall (up to 70%). Perennial grass cover was positively correlated with changes in soil moisture, whereas juniper cover was negatively correlated with soil moisture content. Shallow groundwater response observed in upland and valley monitoring wells indicates temporary hydrologic connections between upland watersheds and valley locations during the winter precipitation and spring runoff seasons. Compared to upland wells, shallow groundwater recharge showed a 4-to-6-week delayed response in wells located downstream in the valley. Study results provide valuable information for understanding seasonal ecohydrologic relationships in western juniper-dominated landscapes.

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Effects of Fuel Reduction Treatments on Post-Wildfire Resilience in the Sagebrush Steppe

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Abstract

Sagebrush steppe ecosystems are becoming increasingly threatened by the invasion of non-native annual grasses, resulting in increased fuel continuity and larger, higher severity fires. In response, land managers are implementing fuel reduction treatments across the sagebrush steppe to mitigate fire behavior and encourage ecosystem recovery following wildfire. The objective of this research is to determine how common fuel reduction treatments (prescribed fire and mechanical) affected post-wildfire fuel accumulation and reburn potential. We collected pre- and 10 years post-treatment fuels data before wildfires burned through four study sites in the Sagebrush Steppe Treatment Evaluation Project (SageSTEP) network, and two additional years of post-fire fuels data. We built custom fuel models using field data and the Fuel and Fire Tools fire behavior modeling program to model reburn fire intensity metrics (flame length, reaction intensity, and rate of spread) and to determine if treatments or site location impacted modeled fire behavior. Site effects had more impact on modeled fire intensity metrics than treatment effects, largely due to the differences in herbaceous fuel responses across sites in the first post-fire year. Burned + untreated control plots had fairly stable fire behavior metrics through time-since-fire, but the burned + prescribed fire and burned + mechanical plots had highly variable responses across all three fire behavior metrics. Site specific responses are likely a combination of land-use history, wildfire intensity and severity, and local climate conditions and on-going research is needed to pull apart the respective influences of each factor. Understanding how fuel reduction treatments and wildfires interact and affect the ecosystem is key to making management decisions in a landscape experiencing increasingly larger and more frequent fires.

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Breaking dormancy and increasing restoration success of native forbs with innovative seed coating and planting techniques

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Abstract

Many plant species exhibit strong dormancy. While this attribute benefits the species' long-term survival, it can present a challenge within a restoration scenario where rapid establishment is required. Soaking seeds in gibberellic acid (GA_3) can overcome dormancy and increase germination but this treatment may not be effective outside the laboratory. An easier and potentially more effective method to apply this hormone is to coat seeds with a GA_3-impregnated polymer, which provides a slow release of the active ingredient. Seed dormancy can also be mitigated by creating a favorable microsite when planting that has increased soil moisture. We compared the emergence and survival of penstemon seeds that were coated with GA_3 to uncoated seeds planted in traditional drill rows versus deep, U-shaped furrows. These treatments were evaluated in late fall and early spring plantings in three field sites in the Great Basin Region of the western United States. Overall, the GA_3 coating improved the emergence and survival of Palmer's penstemon (*Penstemon palmerii*; $p < 0.01$) and thickleaf penstemon (*Penstemon pachyphyllus*; $p < 0.001$) but did not affect the emergence or survival of firecracker penstemon *(Penstemon eatonii*; $p = 1$). Between our two planting seasons, fewer seedlings emerged or survived from spring planting than from fall planting ($p < 0.001$). Emergence and survival were higher for all species in deep furrows than in shallow drill rows ($p < 0.001$). These results indicate that GA_3 seed coating and deep, U-shaped furrows may improve the restoration success of some native forbs by breaking dormancy and providing a favorable microsite. These techniques could be used by land managers in post-disturbance restoration efforts.

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Control of Russian thistle (Salsola spp.) on California's Central Coast Rangelands

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Abstract

Russian thistle (Salsola ssp.) is a problematic weed on California's dry Central Coast rangelands. It can exclude native species and increase fire risk. The high density of plants can make it difficult to traverse rangelands, particularly after spine emergence. Dry Russian thistle skeletons also get caught in fences, which creates a sail effect that can disrupt the integrity of the fence. In 2015, the third year of a severe drought, ranchers began seeing this plant in higher densities and in areas they had not seen it growing previously. Therefore, we deployed a study to test the effectiveness of grazing, herbicide, seeding, and a combination of these treatments on the control of Russian thistle. The herbicide treatment, which consisted of a spring treatment of chlorsulfuron + 2,4-D, followed by glyphosate in the autumn prior to seeding, and 2,4-D the following spring was the only treatment that had a significant effect on reducing Russian thistle cover. However, the other treatments have other ecological and management values. Therefore, we support using all three treatments to achieve a variety of management goals on Central Coast rangelands.

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Latent Dirichlet Allocation (LDA) to aid in understanding patterns of biodiversity and identification of plant communities and states

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Abstract

Rangeland biodiversity underlies multiple ecosystem functions, including the resistance and resilience of local communities under increasing disturbance pressures and ecosystem degradation. Quantifying biodiversity patterns can reveal underlying ecosystem states with relevance for land management. Multiple dimensions of biodiversity are increasingly recognized, from molecular diversity in plant leaves to landscape heterogeneity, but remain difficult to quantify and compare across scales. Latent Dirichlet Allocation (LDA) is a framework that can serve as a unified approach to analyze and investigate biodiversity data across space and time. Two aspects of LDA uniquely position the framework for detecting biodiversity patterns in rangeland ecosystems. First, LDA is a generative statistical model that can be used to simulate and analyze observed patterns of biodiversity. As a generative model, LDA can probabilistically express the patterns of species presence, abundance, and co-occurrence. The probabilistic interpretation of how biological communities are structured lends itself well to decision support in land management. Second, LDA can accommodate diverse types of biodiversity data, from species presence records to quantitative data on species abundance. The flexibility to analyze a diverse set of biodiversity data makes LDA suitable as a cross-disciplinary, unified approach to detecting and understanding patterns of biological communities under various land management contexts. Despite a relatively short history of LDA in ecological disciplines, recent quantitative developments of LDA expand its area of application to explore the relationships between biological communities and environmental drivers of biodiversity. Altogether, LDA represents a unified methodology to detect and analyze natural communities using diverse biodiversity data sources across spatio-temporal scales.

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Effects of imazapic and drought on plant communities in intact Mojave Desert ecosystems

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Abstract

Non-native grasses (e.g., red brome (Bromus rubens) and Mediterranean grass (Schismus spp.)) are prolific throughout the Mojave Desert and have severe consequences for native flora and wildlife habitat. Effects of non-native annual grasses in the Mojave Desert include altered fire cycles, degraded wildlife habitat, and losses in biodiversity. Generally, attempts to control the spread of invasive grasses have been reactive, focusing on degraded habitats with a prior disturbance history (fire, mining, etc.). We investigated the efficacy of proactive herbicide treatments to reduce non-native, annual grass in otherwise intact plant communities. We used a split-plot design to investigate how single or repeat herbicide treatments affected native and non-native plant communities. Pre-emergent herbicide (imazapic) treatments were aerially applied to four 220 x 220 m plots at four sites in Gold Butte National Monument in the fall of 2019. An additional application occurred in fall 2020 on one third of each plot so that each plot had a once- and twice-treated section. We assessed the vegetation community for changes in non-native annual grass and annual forb cover during the growing seasons of 2020, 2021, and 2022. While 2019-2020 winter precipitation was average, extreme drought began summer 2020 and continued through summer 2022. We found small reductions of red brome cover and annual species richness in once-treated plots in spring 2020. No effects of herbicide were found after once- and twice-applied treatments in 2021 and 2022 on red brome cover or annual forb cover; however, these years experienced severe drought which reduced annual plant occurrence in all plots. While imazapic reduced red brome cover in 2020, subsequent drought potentially negated any benefit of using herbicide by negatively affecting all annual emergence. This emphasizes the importance of timing imazapic treatments during years with adequate precipitation to increase efficacy.

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The seasonal effects of residual Ivermectin on nutrient cycling, plant biomass and dung beetle

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Abstract

Knowledge of ecosystem processes in rangelands is vital for global food security since lands are important for forage and livestock production. One of these fundamental processes is nutrient cycling related to decomposition of materials such as dung. Dung decomposition depends on activities of dung beetles that influence nutrient movement into soil and with subsequent uptake by plants. Changes in decomposition can disrupt nutrient cycling and forage production. Usage of anthropogenic chemicals in livestock production can alter decomposition and nutrient cycling through their non-target impact on dung beetles. For example, ivermectin, a commonly used parasiticide can be found in cattle dung and can affect the abundance of dung beetles. The magnitude of the effect of parasiticides may depend on time of year because the activity and abundance of dung beetles change during the growing season. The goal of this study is to examine the effect of residual ivermectin in cattle dung on beetles, soils, and plants during spring and summer. In this experiment, dung pats with zero, low (2 mg kg-1 dung), and high (10 mg kg-1 dung) concentrations of ivermectin were placed in grassland in western South Dakota in summer 2019 and spring 2021. We monitored the N content of dung, soil, and plants, and the abundance of dung beetles, and plant biomass for 63 days. Growing season and ivermectin affected abundance of dung beetles but residual ivermectin did not affect the N content of dung and plants in either season. Conversely, in the summer, both concentrations of ivermectin decreased soil inorganic N almost 30% in days 3 and 63. The impact of ivermectin on plant biomass was less than hypothesized both in spring and summer despite seeing a direct impact of this chemical on dung beetle abundance.

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The principal framework of dung beetle restoration

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Abstract

Dung beetles have key roles in ecosystems including accelerating the decomposition of dung, improving nutrient cycling, controlling pests, and altering physical (e.g., structure) and chemical (pH, available nutrients) soil properties. Human activities negatively impact dung beetle activity and abundance. For example, the use of chemicals, land cover change, habitat degradation, climate change, and the introduction of exotic species decrease dung beetle abundance. In response to this decrease, these species can be an appropriate target in restoration programs. The restoration triangle is a convenient framework to conceptualize the challenges faced in restoring healthy dung beetle populations in a degraded site. In the restoration triangle, three important factors are considered: environmental conditions, biotic characteristics, and focal restoration species. In the case of restoration of dung beetles, improving environmental conditions includes reducing the threats such as parasiticide usage and alleviating abiotic stressors such as soil compaction. Biotic characteristics are the recovery and improvement of organisms like native mammals and plants. Focal restoration of dung beetles is reintroduction, translocation, and assisted migration of native dung beetles. Restoration outcomes are typically unpredictable, but using the triangle approach can help planners to have a comprehensive overview of all parameters involved in the target species and hopefully increase the probability of successful restoration practices.

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The Rangeland Collaboratory at the US Sheep Experiment Station

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Abstract

Commercial scale range sheep capacity in the Intermountain West is dependent on access to public lands grazing, particularly in montane summer ranges that are also host to a number of important wildlife species. Sheep ranchers, conservationists, and scientists are coming together at the USDA-ARS Range Sheep Production Efficiency Research Unit in Dubois, Idaho to envision new paths towards livestock-wildlife and cultural co-existence on the landscape. This poster introduces the Rangeland "Collaboratory" at the US Sheep Experiment Station, a "living laboratory" where stakeholders with divergent goals for rangelands can experiment to better understand synergies and tradeoffs associated with different management and collaboration practices. The Collaboratory has interconnected social and ecological components following an adaptive management cycle. Now at the preliminary assessment phase of the project, researchers are working to gain stakeholder trust and engagement. We are also re-sampling long term vegetation monitoring plots and gathering relevant data about land use and ecological change. We are using a transdisciplinary stakeholder engagement process to identify key partners and engage the group in a committed, semi-formal process to set location research priorities for the 5-year USDA, ARS National Program 215. At the same time, the range field crew is sampling 30 high elevation plots established in <1960 to assess change in tall forb, open conifer, sage, and grassland plots in the Centennial Mountains following grazing deferment since 2013. This integrated model aims to build trust and transparency in the ARS research efforts, effectively "repurposing" the rangeland research program towards achieving social and ecological sustainability. The Collaboratory is actively seeking partnership with interested ranchers, managers, conservation groups, and students.

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Context Matters: Rethinking Resource Governance Theories for Mongolian Pastoral Systems

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Abstract

Globally, rangelands face interacting pressures from climate, land-use, and socio-economic changes, which threaten herder livelihoods and grassland health. Given these dynamics, it is often unclear how to design policies to support sustainable land use and livelihoods. There are multiple theories for how tenure, rules, social relations and environmental variability intersect to influence pastoral resource governance, but these have largely been developed based on specific social and environmental contexts. Here we attempt to reconcile the current diversity of theories around pastoral resource governance with an empirical dataset on livestock management decisions in Mongolia, where there is debate over proposed rangeland tenure formalization. We assess the relationship between theorized predictors of herder behavior (i.e. formal rights vs. formal rules) and household-level management decisions about pastoral mobility and storage. We compare our findings from a survey of 760 households across four ecozones to predictions from pastoral resource governance theories to assess which theories best match the complex realities on the ground.

We observed a continuum of de facto pastoral governance regimes that roughly map onto a social-ecological gradient defined by i) resource variability and predictability, and ii) the relative prevalence of formal rule-based vs. implicit norm-based governance. We find that rules, social capital, and forage availability are the strongest predictors of reserving pastures, while, social ties and environmental conditions predict mobility practices. While most households reserved pastures regardless of tenure status, those households who do *not* reserve pastures are more likely to lack formal use rights.

Our findings reinforce the importance of avoiding "one size fits all" policies. Herders make decisions in response to environmental productivity and variability over space and time, and social ties and mobility are critical for maintaining access to forage. This may explain why many herders remain skeptical of formal pasture tenure, which could restrict this flexibility.

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Rotational grazing success in Central Asia

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Abstract

Cattle weights increased by 30%, milk yield doubled, and per capita income from sales of animals and livestock products also doubled. Range condition improved. These are the results from a range and livestock development project implemented in a poor region of Tajikistan, a former Soviet republic in Central Asia, where 80-90% of households own livestock and depend on them for subsistence and livelihood. Cows' milk is the main commodity and food source. A primary feature of the project was adoption of rotational grazing on 130,000 ha of communal rangeland in 400 villages. The project is the Livestock and Pasture [rangeland] Development Project (LPDP) funded by the International Fund for Agricultural Development (IFAD) from 2013-2021 in ten districts of Khatlon region in southwest Tajikistan. Khatlon is the poorest region of the country with the highest concentration of livestock. Poverty prevails: The average household owns 5 sheep and goats, 1 cow, some chickens and perhaps a donkey; peak daily milk yields were only 6-8 liters. Prior to the LPDP project, the rangelands were degraded and severely eroded. The landscapes are mountainous, snow-covered in winter. The grazing season lasts from April to September; in winter livestock are kept in barns or other shelter and fed fodder crops and hay. Following dissolution of the Soviet Union in 1991, feedlots closed, livestock were dispersed among individual households and range-fed animals assigned to communal rangeland where grazing was unregulated. A government law passed in 2013 created a protocol for decentralized management of communal land under the direction of elected village committees. LPDP was the first project to apply the new law. The paper discusses the implementation and benefits of rotational grazing, a project requirement.

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Carbon Security Index (CSI)

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Abstract

Rangeland carbon is often conceptualized as being similar to croplands, in that we need to sequester more carbon in the soil. However, unlike cropland soils, arid and semi-arid rangeland soils cannot sequester more carbon due to pedogenic limitations. Thus, we need a new paradigm for rangeland carbon that focuses on maintaining and securing carbon from fire and erosional losses, and detrimental vegetation type conversions. We propose the creation of an index called the Carbon Security Index (CSI). CSI incorporates cover of plant functional groups as a ratio (desirable and undesirable), wildfire probability, and resistance and resilience (RR). The index is a unitless, scalable value that can be used to compare carbon stability (i.e., security) at different rangeland sites. The range of CSI values varies between -2 and +2. Low CSI values would be indicative of greater undesirable functional group cover, higher wildfire probability, and lower RR, which translates to carbon pools that are relatively less secure over time. High CSI values would have greater desirable functional group covers, lower wildfire probability, and higher RR leading to more secure carbon pools. To assess our index, we collected both field and remotely sensed data within the Northern Great Basin. We found that remotely sensed data often underestimated CSI in “healthy” sagebrush and bunchgrass dominated sites compared to field collected data (CSI 0.70, 0.86 respectively). Degraded sagebrush, crested wheatgrass, and annual grass-dominated sites had greater variability based on level of annual grass invasion and associated loss of herbaceous perennial plants, but CSI ranged between -0.16 and 0.55 regardless of data type. Using CSI provides landowners and land managers an opportunity to assess how secure their carbon is in their pastures or allotments and help them prioritize areas for restoration.

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Botanical Composition and Quality of Beef Cattle Diets on a Burned and/or Unburned Rangeland

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Abstract

Current management paradigms suggest deferring grazing rangeland for two years after a wildfire to avoid additional stress on native plant species, but there is little to no research supporting these recommendations. This experiment was conducted within and adjacent to the burn area of an August 2020 wildfire to evaluate the differences in diet quality, botanical composition, and foraging efficiency of beef cattle on both burned and unburned rangeland. A randomized complete block design with a 2x2 factorial arrangement of treatments contrasting burn versus no burn and June versus September grazing periods was used. Pastures (4 ha) within the burn area were grazed in either June 2021 or deferred to September 2021. Grazing occurred for two days by 20 cow/calf pairs in June and 16 cow/calf pairs in September. Cattle diet composition and masticate samples were collected during 20-minute bite-count periods using six ruminally cannulated cows in each pasture prior to and after two-day grazing periods. Cannulated cows grazed a pasture adjacent to the burn area to compare diet quality and composition between burned and unburned rangeland. Nutrient value of key grass species in the study area were 30% higher in crude protein in the burned area as compared to the unburned area (12.47 vs. 8.53%, respectively) for the June grazing period. Difference of diet quality of standing vegetation was similar in the September grazing period (6.53% CP). Foraging behavior was influenced by the previous year's fire for the June grazing period. Beef cattle grams per minute ($x \pm$ SD; 23.86 vs 7.22 ± 6.78), bites per minute (15.83 vs 9.4 ± 5.95), and grams per bite (1.53 vs 1.02 ± 0.85) were higher in unburned sites versus burned sites during the June grazing period. However, foraging behavior is similar in the burned and unburned areas during the September grazing period.

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Lehmann Lovegrass (*Eragrostis lehmanniana*) Removal Facilitates Black Grama (*Bouteloua eriopoda*) Recovery in the Chihuahuan Desert

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Abstract

Restoration of native grasses in the North America desert southwest has become a rangeland management priority, but restoration has been challenging for numerous reasons including persistent invasive grasses and water limitations. The invasive grass, Lehmann lovegrass (*Eragrostis lehmanniana*), may interfere with restoration of the important native forage grass species, black grama (*Bouteloua eriopoda*). Superabsorbent polymers (SAP) absorb, retain, and slowly release large amounts of water via their cross-linked structure, and when used as soil amendments, they can increase plant available soil water. To determine if *B. eriopoda* cover could be increased through *E. lehmanniana* removal and subsequent restoration practices, we tested the effects of herbicidal *E. lehmanniana* removal, *B. eriopoda* seeding, and SAP soil amendment on *B. eriopoda* cover over three years at two sites in the northern Chihuahuan Desert, New Mexico. Drought prevented SAP and seeding from being effective. Glyphosate reduced *E. lehmanniana* cover from 14% to less than 1% from 2017 to 2018 at one site. *Bouteloua eriopoda* cover increased from 10% to 16% in response to *E. lehmanniana* decline at this site; however, cover declined to 10% in 2019 as a result of extreme drought. At the other site, *E. lehmanniana* cover declined to nearly 0% in all treatments, and *B. eriopoda* did not establish. No plants at this site recovered by 2019. Results indicate that despite drought-induced challenges of restoration, removal of a dominant invasive grass may lead to increases in desired native species. Nonetheless, extreme drought may have more dramatic effects on vegetation cover than herbicide, hindering restoration.

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Seed Coating Technologies to Reduce Fungal Growth and Improve Germination Rates of Gambel's Oak (*Quercus gambelii*)

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Abstract

Gambel's Oak (Quercus gambelii) is an ecologically important species that provides food and shelter for many wildlife species. Additionally, in areas impacted by disturbance Q. gambelii is often the first woody perennial species to reestablish. The use of this species could be beneficial for the reclamation of mine sites in mountain shrubland areas of the western United States. However, due to the recalcitrant nature of Q. gambelii acorns (i.e. seeds that do not survive after drying or freezing), viability can quickly be lost after the acorns are harvested. Our goals for this study are to improve the germination rates of acorns by applying a seed coating that will help maintain the moisture content in the acorn and promote germination and plant growth. Studies were implemented during the fall of 2021 and 2022 on a mineland-rock dump in central Utah. Seeds were treated with and without a bio complete compost seed coating, within a randomized block design, with seven replicates. We also developed a method for priming seeds in a compost and coconut fiber medium. In addition to accelerating germination, we have found that this treatment decreases fungal activity and improves plant growth. Trials were also conducted in the laboratory in Petri dishes, where we found the seed coating had faster rate of germination and increased total germination by 69% in comparison to the control. Faster rates of germination from a compost coating may lead to larger seedlings that would better survive winter conditions and wildlife predation. Additionally, using compost as a coating could lead to healthier plants by reducing fungal and bacterial diseases and improving soil fertility.

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Plant-Soil Relationships: Long-Term Monitoring of Soil Nitrogen and Moisture after Cheatgrass Chemical Control

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Abstract

Using Pre-emergent herbicides to mitigate the deleterious effects of weeds and wildfires is an effective means to facilitate sustainable delivery of goods and services from Great Basin Ecosystems. Assessing the multiyear effects of such herbicides as Imazapic and Indaziflam on cheatgrass populations can help land managers and agricultural producers maximize natural resources. Understanding changes in soil properties like moisture and nitrogen in relation to weed control and plant-soil relationships can provide insight to mechanisms that enhance the conservation and restoration of Great Basin Rangelands. We sampled soil at three field locations in Nevada (TS Ranch, Bedell Flat and Izzenhood) after pre-emergent herbicide weed control treatments, measuring moisture and available nitrogen. Samples were collected monthly for 4 years. Seasonal patterns of soil moisture and nitrogen were determined based on soils data. Mean Nitrate for the sampling period found that cheatgrass dominated habitats at TS Ranch had less than 10 ppm Nitrate compared to 61 ppm the first year after cheatgrass control. Even 4 years after initial herbicide control Nitrate averaged 27 ppm, more than 3 times as much as untreated cheatgrass plots. Initial (1-2 Years) soil moisture was nearly double in herbicide treated plots compared to cheatgrass untreated plots. Successful seeding efforts were correlated with herbicide treated plots with higher soil nitrogen and moisture. Cheatgrass competition for soil resources results in soil nitrogen and moisture limiting perennial seedlings survival which maintains cheatgrass dominance, high fuels and increased wildfire risk. Decreasing cheatgrass densities using pre-emergent herbicides is an effective means to increase soil resources to promote successful rangeland restoration efforts.

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Indaziflam and Imazapic Comparisons for Reducing Annual Grass Fuels in Forage Kochia (Bassia prostrata) Green Strips.

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Abstract

Green-stripping is the practice of establishing fire resilient vegetation to reduce the occurrence and or size of wildfires. "Immigrant' forage kochia is an ideal candidate for green strips because it remains green and succulent throughout the summer and can be readily established by arial seeding. The effectiveness of a green strip relies on very little dry fuel occurring in the green strip. Thus, cheatgrass must be suppressed to keep fuel levels low. Suppressing cheatgrass (fuels) requires a competitive perennial plant that utilizes soil resources in the soil seedbed zone, leaving insufficient soil resources for cheatgrass to germinate, establish and produce seed. Forage kochia, being a deep tap rooted evergreen shrub, is not as effective at utilizing seedbed soil resources and suppressing cheatgrass occurrence compared to shallower fibrous rooted perennial grasses. This can often lead to a dense cheatgrass interspace and understory in forage kochia stands. We examined the effectiveness of two pre-emergent herbicides, Imazapic and Indaziflam applied within a forage kochia stand occupied by cheatgrass. Both herbicides were effective at controlling cheatgrass, however Imazapic plots experienced forage kochia plant damage and mortality, whereas we observed no negative effects on forage kochia from Indaziflam applications. Multiple application rates, surfactant additive and decreased water volume were examined with Imazapic treatments. We observed and recorded forage kochia plants throughout the growing season and recorded plant vigor and mortality. The reduction of cheatgrass improved plant vigor, yet experienced a level of mortality in Imazapic treated plots. Reducing annual grass fuels in green strips is an important tool in an integrated range wildfire management program. Our results find that pre-emergent herbicides can be very effective at achieving this.

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Vegetation and Animal Production in Pastures Sprayed for Western Ragweed Control

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Abstract

Western ragweed (*Ambrosia psilostachya*) is a native forb found throughout Kansas rangelands. Western ragweed can form dense colonies from growth of lateral creeping rootstalks. Cattle utilized up to 50% of the western ragweed in moderately stocked pastures from past long term grazing trials. However, producers still question if cattle utilize western ragweed and achieve adequate gains in pastures with high densities of western ragweed. We conducted a grazing trial to determine if controlling western ragweed improved animal gains. Stocker animals were allocated in two years into eight, 35-acre study pastures consisting of limy upland ecological sites. One pasture in each of four replicates was treated with dicamba at 6 oz/acre shortly after animal stocking in 2021 to control western ragweed. Western ragweed densities the year prior to the study were not different between treatments and averaged 11.1 plants/ft^2. Ragweed density was much lower in 2021 in sprayed pastures compared to unsprayed pastures (1.2 vs. 4.5 ragweed plants/ft^2, respectively). In October, at the end of the season, available ragweed yield (317 vs. 0 lb/acre, respectively) and ragweed as a percentage of total dry matter available (14.4 vs. 0%, respectively) was greater in unsprayed pastures. Available grass yield (1976 lb/acre) and total yield (2135 lb/acre) were not different between spray treatments in October. Animals in sprayed and unsprayed pastures had similar early season gain, late season gain, and total gain (211 lb/hd). Ragweed density and biomass traits were similar in 2022. Producers often view western ragweed as a weedy forb, but this study showed ragweed had no effect on grass yield, total pasture yield, or animal gain. The ultra-low-cost treatment to control ragweed was an added cost with no significant financial return.

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Innovative use of NAIP and LiDAR Imagery to Identify Potentially 'Undisturbed' Land in South Dakota and the Great Plains: Implications for Retention of Native Grasslands.

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Abstract

South Dakota State University in partnership with federal, state, and non-government conservation organizations developed a new methodology to determine the extent of potentially undisturbed land (i.e. native/virgin) (PUDL) as an indicator of intact native grasslands, wetlands, and woodlands in South Dakota from 2012 to the present.

We employed simple GIS methods primarily utilizing the South Dakota Farm Service Agency's Common Land Unit (CLU) data layers and US Department of Agriculture's National Agriculture Imagery Program (NAIP) county mosaic aerial imagery to evaluate eastern and western South Dakota.

We utilized the CLU data layer, queried to show current and former cropland, to identify and remove any areas with a recorded cropping history. We then employed our methodology to systematically analyze remaining land in approximately one mi2 sections in order to identify and remove additional historic or current land disturbances. The remaining land tracts were categorized as potentially 'undisturbed grassland' or 'undisturbed woodland'. We removed all known water bodies larger than 40 acres as defined by the South Dakota Department of Game, Fish, and Parks' (SDGFP) Statewide Water Bodies layer in order to gain a more accurate interpretation of the remaining undisturbed grassland/wetland/woodland complex.

During the second phase of the project, we developed a protocol utilizing Light Detection and Ranging (LiDAR) data to assess historic land disturbances not otherwise evident in aerial imagery, and then applied this analysis to our PUDL land layer, further refining our final 'native' land layer. Portions of our protocols have been adopted by others, impacting the future of Great Plains grasslands research, protection, conservation, and utilization by both agencies and the public. Finally, we have made the data publicly available for both conservation planning and recreation through a unique partnership with state and federal organizations.

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Thinning dense big sagebrush to replenish herbaceous understories

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Abstract

Throughout the northern Great Basin there are dense or degraded stands of Wyoming big sagebrush (Artemisia tridentata Nutt. ssp. wyomingensis Beetle & Young) with >15% canopy cover. These stands may appear ecologically diverse and healthy, but close monitoring reveals depleted herbaceous understories with little growth of native perennial bunchgrasses and forbs. This not only means reduced grazing capacity for livestock, but reduced forb production for wildlife consumption. However, complete eradication of sagebrush invites problems with annual grass invasion and eliminates potential habitat for sagebrush-obligate wildlife. We hypothesized that low rates of tebuthiuron (<1.0 kg ai/ha) and seeding native grasses and forbs would reduce sagebrush cover enough to maintain its presence and increase native perennial plant densities and cover. To test our hypothesis we established a replicated full factorial study at the Northern Great Basin Experimental Range in Harney County, Oregon with four tebuthiuron treatments (0, 0.11, 0.23, 0.45 kg ai/ha) and four seeding treatments (control, broadcast, drill, and drill-broadcast). We applied herbicide treatments in November 2021 to Wyoming big sagebrush stands averaging 15.86% cover across all plots. In March 2022 we seeded our assigned plots. The first year after treatment, tebuthiuron applications did not significantly affect mature big sagebrush cover, with 13.53% shrub cover on untreated plots, and 12.18% cover on tebuthiuron-treated plots without a seeding treatment. However, drill and drill-broadcast treatments reduced shrub cover to an average of 6.2% on plots without tebuthiuron treatments, due to the rangeland drill knocking down sagebrush. Meanwhile, established perennial bunchgrass density was relatively unchanged by tebuthiuron in the first year, averaging 0.46 plants m-2 for unseeded, untreated plots, compared to 0.31 plants m-2 for unseeded plots with tebuthiuron applied. Over time, we expect tebuthiuron-treated plots to show an increase in perennial bunchgrass density over control plots.

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Use of NAIP and LiDAR Imagery to Determine the Rate of Loss of Native Grasslands in Eastern South Dakota from 2012 – 2021.

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Abstract

South Dakota State University in partnership with federal, state, and non-government conservation organizations developed a new methodology to determine the rate of loss of potentially undisturbed land (i.e. native/virgin) (PUDL) from 2012 to 2021. This research built upon methodology developed while inventorying all South Dakota native habitats during the same period. Those initial efforts set a baseline for native lands circa 2012 by which were able to assess an average rate of loss over the following decade (approximately).

We employed simple GIS tools along with the US Department of Agriculture's National Agriculture Imagery Program (NAIP) county mosaic aerial imagery and Light Detection and Ranging (LiDAR) data to estimate the rate of loss of native grasslands in 44 eastern South Dakota counties.

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Do cover crops enhance the success of prairie plantings? A cautionary tale from Eastern South Dakota.

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Abstract

South Dakota State University in partnership with federal, state, and non-government conservation organizations began experimenting with the use of cover crops as a 'pre-treatment' for agricultural fields for one to two growing seasons prior to installation of diverse native prairie species.

Our collective assumption was that recent and persistent agricultural chemical carryover in farmland soils was detrimentally impacting both germination and establishment of certain native species in some grassland plantings, including various USDA program plantings such as Conservation Reserve Program projects and others. By pre-cropping with cover crops, we hoped to utilize an inexpensive suite of plants to allow any agricultural chemical carryover to effectively volatilize or otherwise exit the system. We also assumed that cover crops would help amend the soil and improve overall soil biological activity and health, therefore creating a more receptive seedbed for native species to germinate and establish.

We 'pre-cropped' several tilled and no-till agricultural fields in eastern South Dakota with a multi-species cover crop mix from 2019 to the present in an attempt to compare against various traditional and successful grassland planting methodologies common to our region. Initial results suggest that planting cover crops for one or two growing seasons prior to planting native species in agricultural fields may not effectively improve native stand establishment and may even be detrimental to establishing diverse stands. We believe that grassland restorationists and professional conservation staff charged with advising private landowners on best management practices for establishing grasslands should use caution in suggesting pre-cropping with cover crops until more controlled research can be performed on these questions.

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Cheatgrass increases flammability of native perennial grasses in laboratory-based combustion experiments

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Abstract

Flammability of the invasive annual grass cheatgrass (*Bromus tectorum*) increases fire risk and causes plant community shifts in the Great Basin (USA), yet no studies have quantified its flammability in comparison to and in combination with native perennial grasses. Understanding cheatgrass flammability throughout a fire season is necessary to inform predictions of fire behavior and effects, and appropriate management decisions for invaded areas. To address this knowledge gap, we conducted burn experiments with cheatgrass and two native perennial bunchgrasses (Bluebunch wheatgrass *Pseudoroegneria spicata* and Columbia needlegrass *Achnatherum nelsonii*) across a range of typical fire season fuel moistures (5-55%). We burned 20 g of perennial grass with 2.5, 5, 10, and 15 g of cheatgrass. Grasses were collected in the field, oven dried and then rehydrated to desired fuel moistures. Flammability was assessed by recording temperature, flame length, and mass consumption throughout each burn. As expected, drier grasses were more flammable. Cheatgrass sustained high ignitability and mass consumption even at the highest moisture levels, suggesting that this species increases ignition and fire spread probability even before plants have senesced. Perennial grasses mixed with cheatgrass, even in small amounts (25% cheatgrass biomass: 5 grams of cheatgrass with 20 grams of perennial grasses), had increased flaming duration, maximum temperature, and mass consumption compared to when perennials were burned alone. When mixed with perennial grasses, cheatgrass fuel moisture did not impact perennial grass flammability, suggesting that cheatgrass poses a threat throughout the season, not only under dry conditions. The two perennial bunchgrass species differed in their flammability response. Data from the burn experiments support previous qualitative observations of cheatgrass altering fire behavior and can inform risk thresholds for cheatgrass presence on a landscape throughout the fire season.

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Belowground storage in grassland systems: the impact of seasonal fires on non-structural carbohydrate reserves in native forbs

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Abstract

Fire is a primary driver for the maintenance and restoration of rangeland systems. However, invasive species, fire staff availability, and other management constraints (like drought timing) have led to variable timing of wildland and prescribed rangeland fires. While it is known that high fuel loads with their greater energy release lead to increased air temperatures, soils (where rooting systems are located) are less impacted by these temperatures. Therefore, fire effects on aboveground regrowth is likely driven by fire effects on belowground meristems (i.e. bud banks) and their supply of carbohydrates that will support their outgrowth. To understand how native belowground plant tissues respond to experimentally manipulated seasonal fires, soil cores (6 in diameter) with native species were extracted from Buffalo Gap National Grassland (South Dakota) during the early (nearly pre-emergent individuals) and late Spring (mature individuals) of 2021. To simulate seasonal wildland fires, samples were burned (in Spring or Summer) via fire tables at fuel loads mimicking 3 tons per acre. An additional treatment of carbon starvation (watered yet kept in darkness) was introduced, alongside seasonal burns, in order to determine extreme impacts on belowground storage (via non-structural carbohydrates; NSCs). At species senescence, we measured starch content at the root and crown (bud bank) level of all samples to compare across treatments and with pre-emergent NSC levels. Initial results indicate that while air temperatures may be extremely high, there is a precipitous decrease in temperature at the soil surface and subsequent depths which reflect minimal soil heating even at high fuel loadings. While species and treatment type/timing have variable impacts on non-structural carbohydrates, individuals with more time to recover following a disturbance were more likely to possess more stored energy (i.e., starch). Therefore, burn timing can impact stored carbohydrate reserves available to the plant in subsequent growing seasons.

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Annual grass control and plant community response to aerial application of indaziflam

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Abstract

Invasive annual grasses continue to negatively impact western rangelands. Cheatgrass (*Bromus tectorum*) and other annual grasses alter fuel structure and composition and create a shift towards more frequent, high intensity fires. An herbicide with a long soil residual, such as indaziflam, can deplete invasive plant seedbanks while releasing remnant native plants from competition. We established a study near Hailey, Idaho in Mountain Big Sagebrush (*Artemisia tridentata* ssp. *vaseyana*) plant communities to assess plant community response to indaziflam treatment. Indaziflam was applied to 19 ha at 47 L/ha by helicopter in September 2020. We stratified the study area into plant community types based on remotely sensed estimates of shrub and perennial herbaceous vegetation cover and located 32, 900 m^2 permanent assessment plots within treated and untreated areas. We measured foliar cover and fuel continuity one and two years post-treatment along 3, 30-m long transects per plot. Fuel continuity was assessed by measuring gaps between alive or standing dead vegetation greater than 20 cm. Indaziflam treatment significantly reduced annual grass foliar cover across all plant community types (mean untreated cover: 11% and 38%; treated cover: 4% and 10% in 2021 and 2022, respectively), and annual grass control was highest two years after treatment. We observed higher species richness and diversity two years after treatment, but no differences between treated and untreated plots. Fuel continuity was lower in 2022 than 2021. As expected, areas with high sagebrush cover had fewer and smaller gaps, and overall higher fuel continuity than areas with lower sagebrush cover. There were no differences in gap size or abundance within each plant community type by herbicide treatment for both years. Future work will include modeling potential fire behavior within plant community and treatment groups to assess fire risk and spread.

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Ecosystem resilience to prairie dog disturbance offers opportunities for rangeland management

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Abstract

In the western Great Plains, black-tailed prairie dogs (*Cynomys ludovicianus*) have major impacts on vegetation structure, cover, biomass, forage quality, and composition. These vegetative changes, in turn, shape outcomes for both livestock and wildlife. Recent research suggested that shortgrass steppe vegetation is relatively resilient to prairie dog disturbance; within 5 years of prairie dog extirpation due to disease, vegetation metrics had converged between formerly colonized and uncolonized sites. However, it is unclear whether these results also hold in northern mixed-grass prairie, where plant species composition is quite different. We used a large natural experiment to examine vegetation change after prairie dog extirpation in northeastern Wyoming. After a large epizootic decimated prairie dog populations across the region in late 2017, we monitored vegetation on former prairie dog colonies and uncolonized sites through two wet years (2018-2019), a drought year (2020) and a more average year (2021). We found that when a plague event was followed by above-average moisture, formerly colonized sites produced 50-100% more biomass than formerly uncolonized sites. This post-plague biomass increase was driven mostly by perennial cool-season grasses and, to a lesser degree, annual forbs. We did not observe large increases in annual brome abundance on former colonies. The pace and magnitude of the post-plague biomass increase were affected by topoedaphic context and occupation history, but the general trend was consistent across a wide variety of sites. Enhanced forage biomass on former colonies persisted for up to 3 years post-plague and was accompanied by enhanced forage quality for one year post-plague. These results suggest that if rainfall is adequate, active restoration (e.g., reseeding) is not needed to revegetate northern mixed-grass prairie after prairie dog removal. Producers with more operational flexibility (for example, a yearling herd) should be able to take advantage of the post-plague biomass bump more effectively.

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Conserving habitat and species, the role of livestock grazing on California's rangelands

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Abstract

Based on United States Fish and Wildlife Service listing documents, 143 plant and animal species or 51% of all the federally listed threatened or endangered plant species in California are found in habitats with grazing. A review of these documents reveals a complex and varied relationship between grazing and conservation. While livestock grazing is a stated threat to 73% (104) of the species sharing habitat with livestock, 59% (85) of the species are said to be positively influenced, with considerable overlap between species both threatened and benefitting from grazing. While the primary grazing threat to listed plant species is from direct impact to an individual plant from grazing or trampling or overgrazing, grazing is credited with benefiting listed plants by improving or maintaining habitat. For animal species the primary threat and benefit from grazing is impacts to habitat. Federally listed species with benefits from grazing primarily benefit from grazing's control of plant biomass and reduction of thatch. Grazing management can combat anthropogenic threats that alter habitat, such as invasive species and nitrogen deposition, and support efforts to reduce land use change and landscape fragmentation, supporting conservation-reliant species in California. Grazing threats and benefits are noted for species across all of California's non-alpine terrestrial habitats including some aquatic habitats, such as riparian areas, wetlands, and temporary pools.

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Effects of a decade of grazing exclusion on three Wyoming big sagebrush community types

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Abstract

In Wyoming big sagebrush (Artemisia tridentata ssp. wyomingensis [Beetle & A. Young] S.L. Welsh) steppe, livestock grazing as a land use is heavily debated because of its extent across the region and the effect historic overgrazing (heavy, repeated use during the growing season) had on native plant communities. Due to the negative impacts historic overgrazing had on many plant community characteristics, there have been calls to remove grazing entirely from public rangelands. However, most studies used to support the removal of grazing on public rangelands referred to the effects of historic overgrazing, rather than the effects of moderate contemporary grazing (40-50% utilization, altering season of use), which is a completely different grazing practice and has vastly different effects on plant communities. Thus, to better understand the effects of contemporary grazing and grazing exclusion (passive restoration), we compared contemporary grazed areas to long-term (10+) grazing exclosures in three common Wyoming big sagebrush community types: intact, degraded, and exotic annual grass-dominated types. Over two years (2020-2021), plant community characteristics (cover, density, diversity) were measured within five grazed and grazing excluded sites within each community type. The effect of contemporary grazing exclusion slightly varied among community types as Sandberg bluegrass (*Poa secunda* J. Presl) density and litter cover were the only characteristics that had such interaction between grazing exclusion and community type. Overall, contemporary grazing exclusion had minimal effects on plant community characteristics across community types, suggesting that removing contemporary grazing has little effect on Wyoming big sagebrush communities, and likely does not promote recovery of degraded or annual grass-dominated sites. In contrast, most plant community characteristics varied among the three community types and between years, suggesting that spatial and temporal variability found among Wyoming big sagebrush communities likely has a greater influence on plant community characteristics compared to moderate contemporary grazing.

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Exacted easements for conservation on cattle ranches, seeing conservation values but overlooking the value of ranching

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Abstract

In the San Francisco Bay Area, a biological hotspot, over 29% of the land, approximately 0.5 million ha, is considered protected, either owned by public agencies, or under easement, where development rights are held by a conservation entity. Of this protected land, 43% is grazed land. Spatial analysis and a review of case studies was used to examine the reliance on grazing lands to meet conservation objectives, and how partial title acquisitions through a type of easement may undermine the same species conservation benefits they seek to conserve. The role of grazing lands in meeting conservation objectives in the Bay Area was evaluated to determine what conservation activities are valued and who benefits from these activities. Spatial analysis reveals that based on species occurrence, regardless of protection status grazing lands provide the majority of habitat for many threatened and endangered species. Furthermore, over 65% of the land described as essential or important to conservation by a regional planning network is grazed land. An emerging state strategy to support economic development on some land requires compensatory conservation of habitat on other land by partial title acquisition with an exacted easement. The case study of exacted easements on cattle ranches reveals how reterritorialization alters the perceived purpose of the land and its ecosystem services and creates new opportunities for capital accumulation from conservation services that both challenge and support a rancher's place on the landscape. Activities valued and funded by the exacted easements include resource management, infrastructure maintenance, monitoring, reporting, and easement administration. Some activities can only be provided by qualified resource management professionals and solely benefit habitat. Although some funded tasks support land sharing by livestock production and conservation, including maintenance of stock ponds and invasive species control, livestock production is expected to fund most rancher stewardship including grazing management.

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Effects of extreme rainfall events and different functional types on the net ecosystem exchange, biomass and nitrogen mineralization in a Northern Great Plains mixed grassland

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Abstract

Climate change is leading to more extreme rainfall events of larger size but less frequency in the Northern Great Plains. We ask if extreme rainfall influences biomass, net ecosystem exchange (NEE), and nitrogen mineralization rate (NMR) within different grass functional groups. We examined each in a split-plot experiment with two distinct rainfall regimes (frequent/small and infrequent/large with constant total monthly precipitation) and two functional groups (C3- and C4-grass dominated pastures) with five replications in western South Dakota from 2020 to 2022. Extreme rainfall increased soil moisture in the C4 pasture because larger rains added more water to deeper soil , but reduced soil moisture in the C3 pasture by evaporating more water from the shallower layer in prolonged drought. Consequently, we hypothesized that extreme rainfall would (1) reduce CO2 flux, (2) increase plant growth, and (3) increase NMR in C4- but not in C3-dominated pastures. We observed: (1) Extreme rainfall reduced CO2 sink strength in the early season in the C3 pasture, but increased it in the late season in both C3 and C4 pastures. (2) Extreme rainfall did not influenced biomass, but overall biomass in 2021 and 2022 were much greater than it in 2020; and (3) extreme rainfall reduced NMR in the C3 pasture, especially in the early season. We conclude: (1) extreme rainfall increased carbon loss in mesic C3 pastures in the wetter (early) season, and reduced carbon loss in xeric C4 pastures in the drier (mid and late) season; (2) extreme rainfall did not influence plant growth following three years of treatment, but early season soil moisture is more critical for aboveground biomass than rainfall in the late season; and (3) prolonged drought associated with extreme rainfall would break down the original wet-dry cycle and reduce NMR, especially in the early season.

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Traversing the Social & Ecological Dimensions of Collaborative Rangeland Management Through Ecosystem Services Valuation

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Abstract

For millennia, Western United States rangelands have supported large herds of migrating herbivores who have contributed to the maintenance of these ecosystems over time, a sort of co-evolution. More recently, populations of native herbivores have drastically diminished on vast tracts of these rangelands, including public lands. Government agency partnerships with cattle ranchers may fill this ecological gap and contribute to additional sociocultural and socioeconomic benefits. To learn more about collaborative grazing management on Colorado's rangelands, we investigated four northern Front Range partnerships between private ranchers and government agencies. We evaluated these landscapes as complex social-ecological systems.

Building off social-ecological systems theory, the ecosystem services concept highlights linkages between people and nature, directly addressing relationships and the flow of values. The ecosystem services framework is boundary-crossing and has spurred countless global scholarly and policy efforts across disciplines. Sociocultural valuation of ecosystem services is a subject of particular interest.

Weaving quantitative and qualitative research methods, we explored the sociocultural values and perspectives of diverse stakeholders regarding rangeland ecosystem services. We noted patterns in how stakeholder groups prioritized certain ecosystem services over others and how this prioritization is a reflection of unique values systems. Stakeholders largely agreed that multi-use rangeland management incorporates conflicting interests and tradeoffs, like recreation versus agriculture. There was consensus that cooperative and collaborative management is an auspicious approach and may open doors to solutions, as stakeholder perspectives are likely rooted in overlapping values.

Through this study we demonstrate that public-private partnerships in rangeland management can nurture sustainability success. Synergies between agriculture and conservation are possible, where cattle may be considered partners in the maintenance or even improvement of ecological function. Sustainable rangeland management is not only about the ecological underpinnings of a place but also about supporting the people and communities who hold direct relationships with those landscapes.

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Timing Prescribed Fire in Tallgrass Prairies Based on Plant Phenology – Lessons Learned

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Abstract

The U.S. Fish and Wildlife Service (USFWS) uses prescribed fire to manage native prairies in the Prairie Pothole Region. Management goals include increasing native plants and decreasing smooth brome (*Bromus inermis*) and Kentucky bluegrass (*Poa pratensis*). The Native Prairie Adaptive Management program (NPAM) provides a decision framework to aid in meeting this goal. Tallgrass prairie management units enrolled in NPAM receive annual recommendations that provide specificity for timing burns based on smooth brome phenology. Literature and expert opinion at the onset of NPAM suggested that burning smooth brome at the elongation stage provided the best opportunity to decrease smooth brome and increase warm-season native plants. USFWS staff worked with partners over the past decade to identify smooth brome growth stages consistently and accurately. Recent retrospective analysis of NPAM tallgrass data indicate that this targeted burn time is not producing the expected results. Burning at the elongation stage of smooth brome is not decreasing the smooth brome cover nor increasing the native plant cover. Conversely, burning outside of this window decreases the smooth brome cover and increases the native plant cover. The results of this analysis reinforce the need to continually challenge our assumptions about managing prairies.

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Impact of fire and drought on axillary bud numbers in Kentucky bluegrass (Poa pratensis L.)

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Abstract

Kentucky bluegrass, a perennial, cool-season, non-native grass, has rapidly increased on rangelands in the northern Great Plains but the underlying mechanism for this increase is unknown. Two potential mechanisms are reduction in burning and increased precipitation. A project was initiated at the Northern Great Plains Research Laboratory (USDA-ARS) near Mandan, North Dakota, USA using rain intercept shelters and fall fire to evaluate drought and burning effects on Kentucky bluegrass axillary bud numbers. Rain intercept shelters (3 x 3 m) were used to intercept 0, 30, or 60% of ambient precipitation during the growing season. Half of each plot under the shelter was burned in the fall of 2017, 2019, and 2020. Treatments were replicated 3 times in 3 separate blocks. In May and October of 2020 and 2021, a 4.78 cm id diameter core was taken out of the burned and unburned portions of each plot. After collection, soil was rinsed from the cores using a 1 mm screen, and loose thatch and root mass were removed. The remaining material was soaked for 24 hours in a 0.1% w/v tetrazolium chloride solution which turns active axillary buds red. Crown material was examined using a dissecting microscope and the number of active buds was recorded. There were significant interactions for drought by burning ($P=0.0642$) and time by burning ($P=0.0020$). Under moderate (30%) drought stress, burned plots produced half of the amount of Kentucky bluegrass axillary buds as unburned plots. In October 2020, burned plots produced about 46% of the Kentucky bluegrass axillary buds as unburned plots. A strong regional drought starting in 2020 and continuing through 2021, may have impacted the effects of drought treatments. This study highlights the importance of understanding interactions when determining the best management strategies.

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Scale, biodiversity, and invasion in the tallgrass prairie: a test of the Invasion Paradox across large working rangelands.

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Abstract

Invasive species are touted as major contributors to biodiversity declines worldwide. However, invasive species effects are suggested to be scale-dependent, and hypothesized to paradoxically be positively related to biodiversity at large spatial scales. Yet, experimental evidence supporting or rejecting the invasion paradox is lacking, particularly across large heterogeneous rangelands. We manipulated eight large (333 – 809 ha) pastures with fire and grazing—pyric herbivory—to test how an invasive legume (*Lespedeza cuneata*) affects tallgrass prairie plant communities at spatial grains ranging from 0.1 m^2 to >3,000,000 m^2. We collected plant species composition and canopy cover data from each of our pastures annually from July 1-31 during 2019-2021. To address how *L. cuneata* abundance and scale affects plant diversity and composition, we modelled three standard measures of diversity (Hill numbers 0-2) and functional group canopy cover against *L. cuneata* cover using Linear Mixed-Models at each spatial grain. The effect of *L. cuneata* changed with spatial grain; most being significantly negative at small (0.1 m^2) spatial grains and neutral or positive at our largest grain sizes (>3,000,000 m^2). However, the variability of plant diversity across our pastures was only weakly explained (i.e., the R-square) by *L. cuneata* abundance across all grain sizes. Therefore, it is unclear whether any meaningful biological effect exists between *L. cuneata* and plant diversity across our study area at any scale. Processes like pyric herbivory are known to promote heterogeneity and biodiversity, and restrict invasive species like *L. cuneata*. Invasive species effects gleaned from small scale, highly manipulated, experimental studies do not reliably predict their effects across large heterogeneous landscapes. Management strategies based on results from small-scale studies of invasion are unlikely to increase or conserve biodiversity across large grasslands. Rather, processes that generate landscape heterogeneity, like pyric herbivory, are probably more important to promoting biodiversity across all scales.

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Quantification of resistance and resilience metrics as a function of elevation and slope and relevance to first year seedling establishment

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Abstract

Invasive annual grasses now dominate millions of hectares of rangeland in the Intermountain Western US. Local annual grass distribution, however, has been shown to follow landscape patterns of slope, aspect and elevation that are correlated with ecological resilience and resistance to annual grass invasion. Soil climate mapping is currently being used to partition landscapes into areas with a high probability of successful restoration versus areas that are considered irrecoverable without an unrealistic degree, and cost, of management intervention. Current management priorities, however, recognize that restoration and rehabilitation of these areas may still be warranted for critical wildlife habitat or areas that provide plant community connectivity in an increasingly fragmented landscape. Additional knowledge of the mechanistic nature of resistance and resilience over the shorter time scale of seedling establishment may improve our ability to restore high priority but problematic disturbed areas, particularly those at lower elevation or of southern aspect. We modeled seedbed microclimate and favorability for germination and seedling establishment as a function of slope, aspect and elevation over 17,400 ha in the Boise Foothills Management Area. We found that higher elevation and northern aspects are more likely to defer germination of seeded species until late enough in the fall to avoid post-germination/pre-emergence freezing mortality. These sites are also more favorable for seedling survival through mid to late summer. Slope, aspect, and elevation effects on potential restoration outcomes are consistent with previously modeled general patterns of ecological resistance and resilience as a function of soil hydrothermal class, but inclusion of slope and aspect effects may produce finer-scale metrics for mapping these patterns over space. The probabilistic nature of microclimatic variability as a function of elevation may yield useful insights into successful restoration approaches for reestablishment of native plant communities in lower-elevation ecosystems with inherently lower ecological resistance and resilience.

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Bi-weekly early estimates of exotic annual grass abundance in rangelands of the western U.S.

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Abstract

Exotic annual grasses (EAGs) have invaded western rangelands for more than a century. In that time, EAG invasion has become widespread and increasingly problematic. EAGs have impacted fire regimes and, in doing so, contributed to the degradation of waterways, altered the carbon balance of rangelands, and threatened high-value societal priorities like recreational areas, grazing lands, and native wildlife habitat. Our objective was to develop spatially explicit estimates of EAG distribution and abundance data quickly at a bi-weekly cadence from May to early July 2022. Integrating remotely sensed data, data from relevant environmental drivers like elevation and soils, and annual BLM Assessment Inventory and Monitoring (AIM) data into machine-learning algorithms and pipelines, we developed a model that estimated EAG abundance. Product latency was about 13 days for each map iteration, providing estimates of EAG abundance at 30-m spatial resolution. The inclusion of 7-day weekly composites of harmonized Landsat / Sentinel Normalized Difference Vegetation Index (NDVI) and Normalized Difference Water Index (NDWI) data into the mapping model provided the maps with temporal variability. The mapping model's accuracy was relatively strong with a training r = 0.94 and a median absolute error (MAE) = 1.64 and a testing r = 0.76 and an MAE = 3.89. The bi-weekly maps showed areas of progressively increasing abundances of EAGs early in the growing season followed by largely stable abundances later in the season. A small percentage of pixels displayed increases in abundance in the final map iteration. Producing rapid estimates of exotic annual grass distribution and abundance in semiarid and arid rangeland ecosystems at critical periods in the growing season provides timely information about landscape conditions that can be helpful for land managers and fire scientists. The five 2022 datasets can be downloaded at https://doi.org/10.5066/P9FVYOGD.

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The effects of Mexican feathergrass density on blue grama seedlings

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Abstract

Introductions of non-native plant species have occurred for millennia yet within the last few centuries increasing global transportation networks have increased these potential ecosystem-altering events. Mexican feathergrass (*Nassella tenuissima* (Trin.) Barkworth) introductions around the world have occurred in recent years due to their appeal as ornamental plants in landscaping in urban and suburban settings. In North America this species had a restricted range in northern Mexico and the Southwestern United States, but recent introductions to more humid areas have allowed populations to establish and expand into newer habitats. Based on previously published work, these new introductions are likely to have significant effects on native plant communities, including the semi-arid shortgrass prairies of Texas. To further investigate this I grew the shortgrass prairie native plant blue grama (*Bouteloua gracilis* (Willd. ex Kunth) Lag. ex Griffiths) in 2-gallon pots with an increasing number of *N. tenuissima* plants in an addition experimental design for two growing seasons, and measured resulting survivorship, biomass and plant length. Increasing density of *N. tenuissima* significantly reduced the growth of the blue grama metrics studied (p-value =0.0071 for shoot biomass; p-value = 0.0021 for root biomass). This common invasive grass will have detrimental effects on native plants in ecosystems of Texas where present and where it could spread.

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Shiny Happy Range: Using Shiny R to develop producer support tools to inform range management

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Abstract

In the era of big data, numerous data streams exist that can inform range management and livestock producer decision making. However, access to this data can be difficult and often requires advanced skills to acquire, process, and analyze datasets to gain insights. A wide variety of decision support tools are available to producers for estimating cattle nutritional needs, calculating stocking rates, and storing and tracking weather or production data within Microsoft Excel. In contrast, open-source software can be used to develop additional tools and data visualizations that leverage the power of statistical programming software with user friendly interfaces. Shiny is a package within the R programming language that facilitates building interactive web applications to visualize and process data. The objective of this project is to highlight two simple and easy to use web-applications to demonstrate how Shiny R can be used to develop tools for land manager decision making. The first web-app, the SDSU Extension Grazing Calculator, helps livestock producers with calculating appropriate stocking rates for each pasture under two scenarios: fixed land/time or fixed herd demographics. The second web-app, the South Dakota Grazing Readiness Spring Turnout Map, uses open-source PRISM climate data to create a map of the average date and range of dates when sufficient growing degree days have accumulated for different species to reach the 3.5 leaf stage for grazing. Shiny R is advantageous in allowing complex calculations and data processing to occur behind the scenes, while allowing for a simple and user-friendly interface. Decision support tools developed using this package can help producers access, generate, visualize, and interpret data relevant to their operation, ultimately enhancing their decision-making, ranch sustainability, and animal performance.

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The effect of diet diversity on goat meat quality

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Abstract

Goats tend to eat many forb and browse species that typically contain many secondary compounds, such as phenols and terpenes which may compromise their palatability. These plants can also be relatively high in protein, carbohydrates, fats, vitamins and minerals. Ruminants have been found to eat more and perform better when a wide variety of plants containing nutrients and secondary compounds are available to them as that variety increases the chance of providing their cells with primary and secondary compounds that are good for their health and nutrition. This study used goats to explore the effect that grazing a high diversity (HD) of plants containing secondary compounds, has on their muscle chemical composition and potential healthfulness for human consumers. By using metabolomic analysis, we aimed to explore how the compounds in the meat of those goats differ from goats who grazed on low diversity (LD) pastures. Twenty-four yearling goats were randomly allocated a finishing diet type (HD or LD) and grazed for 60 days. Muscle samples were collected from each goat post slaughter and were tested for shelf-life, oxidation, drip loss, colour score and tenderness. Metabolomic and fatty acid composition analysis were also conducted on the samples. Currently our samples are still being analysed, and we are awaiting results (expected by late November 2022). Given that many broadleaf plants are highly nutritious, and several previous studies have indicated that animal products of biodiverse pasture-fed livestock generally have a superior nutritional profile we hypothesise that the meat of goats who grazed on HD pasture will be of superior quality compared to LD pasture grazing goats.

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Disturbance and plant community assembly in exotic-dominated landscapes

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Abstract

Exotic-dominated landscapes may arise from invasion by highly competitive plant species, or due to disturbance coupled with exotic early-colonizing species. Without knowing site history, it is difficult to predict how communities will reassemble after disturbance events. This is important to understand, however, given increasing disturbance levels (e.g., fire, development, grazing) across anthropogenically impacted landscapes. We asked how disturbance affected community assembly in six invaded habitat types common in dryland, grazed landscapes on Hawaii Island. We mechanically disturbed 100m2 plots using a front end loader in six habitat types dominated by one of four exotic perennial grasses, one native shrub, (Dodonaea viscosa), or one native perennial grass, (Erogrostis atropoides). We censused vegetation before disturbance and then monitored woody plant colonization and herbaceous cover for 18 months. Some exotic grasses quickly regrew and achieved similar community assemblages within months of disturbance. Slower growing species had a greater amount of bare ground in disturbed plots than undisturbed plots but still retained a similar community composition. Only plots dominated by Melinis repens (an invasive grass) changed overall community composition following disturbance. While there were flushes of native shrub seedlings, these did not survive to 18 months in most habitats (except C. setaceus and D. viscosa), probably due to fast regrowth by exotic grasses. Based on our results, we do not expect disturbance to cause shifts in dominant species in most dryland habitats in Hawaii, and instead predict habitat composition most likely reverts to pre-disturbance community assemblages.

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Cumulative Growth of Forage Production in a Patch-Burn Grazing System

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Abstract

Cumulative growth of forage production includes plant growth, plant regrowth, and forage consumed by the grazing animal throughout the growing season. While the concept of patch-burn grazing is similar to rotational management, it is often criticized for short-term forage loss. This project was designed to evaluate the production potential of a patch-burn grazing system by assessing the cumulative growth of forage production at the NDSU Central Grasslands Research Extension Center. A 3-yr randomized block design was initiated in 2019. However, the project was discontinued during the summer of 2021 due to extreme drought conditions. Three assessment windows were each replicated four times. Clipping periods of two, four and six weeks (with an equivalent rest period) were assigned to the patch-burn grazing and represented treatment time windows. A control was established to represent forage production on non-grazed burns. All units were burned on a 4-yr return interval and the grazing treatments were replicated in areas that had been burned in the spring prior to green-up. Pastures were stocked at a moderate rate with cow-calf pairs designed to achieve an average 45-50% degree of disappearance across the pasture and a 30% harvest efficiency. Cumulative growth of total forage production at the two- and four-week periods were statistically different ($P = 0.0474$) from the control during 2019, however, similar to the six-week period (Figure 1). Cumulative growth of forage production was not statistically different ($P = 0.3474$) for grazing treatments during 2020. It is important to note that growing season conditions during 2019 and 2020 were different. The highest amount of cumulative forage production in the patch-burn grazing system during 2019 and 2020 was 5,663 and 3,754 kg/ha, respectively. Although significant difference was not detected between assessment windows during 2020, a similar trend occurred.

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Reclamation following oil and gas development on the Colorado Plateau governed by abiotic setting and time

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Abstract

The Colorado Plateau contains approximately 100,000 abandoned and active oil and gas wells spanning 60+ years of activity. The physical and ecological footprint of these developments can be quite large and there is uncertainty on where, when, and how these highly disturbed lands can be successfully reclaimed. Our goals are to: 1) determine how soil and climate settings interact with management actions to drive reclamation success and 2) evaluate which indicators of reclamation success improve with time since reclamation. We collected data from 134 plugged and abandoned well pads over two years (2020 and 2021) and across three states (Utah, Colorado, and New Mexico). We sampled from a chronosequence of plugged wells, with locations provided by the Bureau of Land Management (BLM). We quantified a suite of plant, soil, and landscape characteristics and compared key plant community indicators from pads to BLM Assessment Inventory and Monitoring (AIM) plots from similar soil and climate settings. On the reclaimed pads, we found that site aridity, salinity, and rock content were all important abiotic factors governing reclamation outcomes, as was time since reclamation. Pads with shallower soils and greater restrictive depths were less often successfully reclaimed, as were more arid sites and saline soils. Changes over time were minimal, but there were trends of decreasing bare ground and increasing woody cover, especially on rocky sites, indicating increased reclamation success with time. Taken together, this large data set, spanning gradients in time since reclamation, climate, and soils, will be valuable for ascertaining possible reclamation outcomes and success rates following oil and gas and other disturbances, including efforts to reclaim orphaned wells and lands damaged by renewable energy development. Importantly, the analytical approach used here has applicability for setting reclamation outcome standards for agencies and landowners across the region.

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Comparing Net Energy for Activity Between Continuous and Virtual Grazing Systems Using GPS Data and Daily Weights

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Abstract

Past research has laid the groundwork for estimating net energy for activity ($NE_{mr\ act}$) for rangeland cattle based on daily activity. However, there is a need to account for daily variations in weight, daily distance traveled (DDT), elevation, and slope on energetic requirements for rangeland cattle. Precision data can inform cattle energetic models to provide insight into daily variations and differences between management on energy expenditure. This study was conducted over two years at the South Dakota State University Cottonwood Field Station (Philip, SD). Yearling steers (n=125 in 2021 and n=127 in 2022) grazed native summer pastures from May to August. Pastures were composed primarily of native C3 grasses, *Nassella viridula* and *Pascopyrum smithii*, and C4 grasses, *Bouteloua gracilis* and *Buchloe dactyloides*. Vence™ virtual fence (VF) collars were set to record GPS fixes at 5-minute intervals. GPS data was paired with daily weight data collected from Smart Scales™ (C-Lock Inc., Rapid City, SD) located at stock tanks within each of six pastures at three different stocking rate treatments (n=3, light, medium, and heavy stocking rate; 2 reps per treatment). Cattle were rotationally grazed (VF rotation) or were allowed to continuously graze (continuous). $NE_{mr\ act}$ was calculated from an existing methodology with the integration of daily weights and DDT on an individual animal basis. Differences in $NE_{mr\ act}$ among grazing systems and stocking rate were compared with a mixed model ANOVA (P-value < 0.05). Calculating the energetic efficiency of a herd and understanding $NE_{mr\ act}$ between grazing systems allows producers to leverage management decisions such as rotational grazing to maximize net energy for growth (NE_{gr}) and increase daily gains in their herd, translating to higher value cattle.

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Drought diminishes differences among ecological states across a historical grazing gradient

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Abstract

Climate change, drought, grazing management, and invasive plants are commonly cited drivers of land degradation, particularly in drylands. Previous research suggests that historical over- grazing has severely altered the structure and function of some dryland ecosystems, leaving them in various forms of persistent alternative states characterized by increased bare soil, accelerated erosion, and dominance by non-native annuals. We present findings from a 20+ year study in Canyonlands National Park, Utah, investigating variations in biocrust and vegetation cover across a historical grazing gradient that has created three distinct alternative and persistent states: an annualized-bare system that was historically heavily used by livestock (last grazed in mid 1960s), a grass-bare system that historically received only light use by livestock (last grazed in 1971), and a high biocrust and grass system that was never used by livestock. Within the annualized-bare system, there has been a decline in C3 grasses after 2001, both for native bunchgrasses and the non-native annual grass *Bromus tectorum* (cheatgrass). Conversely, in the grass-bare system and the high biocrust system, native perennial grass cover for both C3 and C4 grasses has remained consistent, up until the around 2018 when all sites have experienced precipitous declines in perennial vegetation. Late-successional biocrust components (lichens and mosses) are the most abundant in the high biocrust system, yet that never grazed site has observed recent declines in heat-sensitive biocrust species bringing biocrust composition closer to that of the grass-bare system. The grass-bare system has the highest cover of non-native plant species including both *Bromus tectorum* and *Salsola tragus* (prickly Russian thistle). These findings suggests that climate change and the ongoing megadrought in the southwestern US are negatively impacting biocrust, and vegetation, even in protected areas.

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Exploring Spatial and Dimensional Differences Across Multiple Resolutions in Image Classification

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Abstract

Image classification has proven to be an invaluable resource in remote sensing. This tool has been implemented to answer questions across a broad range of disciplines and topics, from geographic mapping and surveillance to agriculture and evaluating environmental change and more. Recently region wide, national, and even global products are being produced. When users look to these products for answers it is important to know how to apply these products, their strengths and limitations.

A user should start with and understand their own unique question and determine its spatial context. For example, at what resolution does imagery need to be. And what temporal scale is need. With these requirements in mind an informed user can select the best image classification platform to meet their needs. This presentation will explore these questions and give examples of the differences between national larger resolution datasets and smaller resolution regional datasets

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Spatiotemporal variation in grazing intensity in the Thunder Basin ecoregion (TBER)

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Abstract

The 11 states in the American West represent approximately 20% of the U.S. beef cow inventory, with approximately 6.4 million cows. Despite the extent of western livestock production, ranchers are often limited by the quality and quantity of forage available in semi-arid rangelands. Given these limitations, ranchers are dependent upon the use of public rangelands for livestock grazing in order to supplement the amount of available forage. Grazing is a permitted use on 270 million acres of public lands across the West, but public lands are federally mandated to be managed for multiple uses including natural resource harvesting, energy extraction, conservation, and recreation, in order to best meet the needs of the American people. The degree to which the goal of managing for multiple uses is achieved, coupled with the competing interests of varied stakeholder groups, can create conflict over land use that threatens sustainable resource management. Given the widespread dependence by private ranches on public grazing permits and the tight connections between private and public land uses, conflicts over public lands grazing management have the potential to impact agricultural production and ecosystem sustainability in the US. Therefore, understanding how public land is managed in the context of diverse stakeholder perspectives is critical for both maintaining functioning ecosystems and supporting rural economies. Through a detailed analysis of United States Forest Service (USFS) rangeland management records, we investigated how and why livestock grazing on public lands changed since the 1940s in the Thunder Basin ecoregion (TBER) of northeastern Wyoming, in response to shifting paradigms in rangeland management. Findings from this project will provide insights into how and why grazing has changed on public lands in response to diverse stakeholder needs. Understanding these factors is critical to our ability to maintain sustainable working landscapes that support western livelihoods, communities, and ecosystems.

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Does Origin of Yearling Steers Influence Weight Gain when Grazing on Shortgrass Steppe?

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Abstract

Grazing by yearling stockers is a significant enterprise for many ranchers in the North American shortgrass steppe. Origin of yearlings prior to grazing this rangeland could impact animal performance, but quantification is lacking. We hypothesized that yearlings originating from within this region (i.e., “local”) would exhibit greater weight gains than naïve yearlings originating from other regions. We compared animal performance of yearling steers originating from a “local” ranch in northeastern Colorado to yearlings originating from 1) a high-elevation area in southeastern Wyoming, and 2) a tallgrass area in south-central Nebraska. Forty steers from each origin grazed on shortgrass steppe from mid-May to October with individual animal weights obtained at the beginning and end of each three grazing seasons (2019-2021). 2019 and 2021 were similar with abundant spring precipitation followed by a dry summer (July-September); we observed consistent ordering by origin of steers for weight gains in these years. “Local” steers gained 1.077 and 0.951 kg/steer/day in 2019 and 2021, respectively, with weight gains reduced 11.5-23.2% for the high-elevation steers (0.827 and 0.842 kg/steer/day in 2019 and 2021, respectively), and 20.1-30.8% reductions for the tallgrass steers (0.760 and 0.745 kg/steer/day in 2019 and 2021, respectively). 2020 was a drought year resulting in forage deficits that substantially reduced, by 15-25%, average daily gains of “local” steers (0.811 kg/steer/day); no differences in weight gains were observed between origins of yearlings. Diet quality (crude protein and digestible organic matter) did not differ among yearlings with different origins in any year. We suggest enhanced weight gains by “local” steers compared to naïve steers in non-drought years could be attributed to 1) rumen microbiome communities specific to existing vegetation, 2) experiential knowledge of steers influencing grazing behavior dynamics, and 3) matching of cattle genetics to the specific environment.

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Supplement Type and Factors Affecting Use by Cattle in a Montane Riparian Pasture

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Abstract

Prior research has demonstrated that providing upland nutritional supplements can reduce utilization of riparian vegetation by altering cattle grazing distribution. However, knowledge of the factors affecting supplement use in pastures containing riparian areas common to the rugged coniferous forests of the intermountain west is limited. Consequently, we evaluated the disappearance of protein (CP) and mineral (M) supplements by cow/calf pairs during 4 years of a grazing experiment in the Meadow Creek allotment in the Starkey Experimental Forest and Range in northeastern Oregon, USA. We separately analyzed disappearance rates (lbs/hd/day) of protein and mineral supplements using generalized linear models with covariates describing the landscape around each supplement site. We considered covariates for season (early vs. late), slope, distance to upland water sites and to the riparian area, canopy cover, sine and cosine of aspect, convexity, and a measure of greenness (amplitude). We allowed for multi-scale relationships by averaging values on a 30-m grid using 100-, 200-, and 300-m buffers around each site. We then used the small-sample version of the Akaike Information Criterion (AICc) and a stepwise model-building process to reach the final models. We found the best predictor of supplement use was average slope around a site, and that rates decreased dramatically with just a slight increase in average slope within a 200 m buffer. In addition, CP disappearance was higher at locations closer to watering sites and with more canopy cover within 100 meters. The consumption rate of M supplements was higher in the early-season at locations with no slope or mild slopes facing east (300-m buffer) and declined as the number of days in the pasture increased. In conjunction with information on pasture access and road/trail networks, we can use our final models to identify optimal locations to encourage supplement use by beef cattle.

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Practical Considerations for Adaptive Strategies by US Grazing Land Managers with a Changing Climate

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Abstract

We outline practical considerations for grazing land adaptations with a changing climate, with an emphasis on the ranch/operation scale and specific attention to directional climate changes and increased climate variability. Two overall themes of these adaptive strategies are flexibility and learning under uncertainty. Ranches/operations with greater land, social, or other capital resources may have more inherent flexibility. Conservation programs and/or market-based approaches can increase flexibility and reduce risk for managers. Bolstering adaptive capacity across landscapes and time can originate from social capital of managers and strategic collaborations, especially given bigger peer support networks and widely accessible web-based information. As climate diverges from historical baselines and the realm of manager's experiential knowledge, new conceptual frameworks are needed to frame conversations, influence research relevancy and impact, and drive imaginative solutions among researchers, managers, and local communities for socio-ecological systems. Practical considerations for adaptive strategies by grazing land managers with a changing climate will be accelerated through 1) collaborative efforts becoming more mainstream, 2) co-produced research with managers and researchers at ranch-scales, 3) development of communities of practice and associated learning opportunities, and 4) continued development and advancement of technologies and tools.

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A web interface for calculating ecological indicators using *terradactyl*

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Abstract

Land management depends on access to information regarding ecosystem attributes and services but raw monitoring data often cannot be readily interpreted to answer management questions. However, those data can be used to calculate ecological indicators—statistics which can provide insight regarding ecological health and function. Common ecological indicators include vegetation cover, soil stability ratings, mean vegetation heights, and gaps in foliar canopy. The R package *terradactyl* has been developed for the purpose of calculating ecological indicators from data in a standard but flexible way and is currently used by the Bureau of Land Management's Assessment, Inventory, and Monitoring (AIM), the National Resources Conservation Service's National Resources Inventory (NRI) and Conservation Effects Assessment Project-Grazing Lands (CEAP-GL), and other research programs. Previously, using *terradactyl* has required the user to write R code in order to process their data but now we present the Rangeland Indicator Calculator, a web application that provides a no-code interface for applying *terradactyl* and calculating both common and custom rangeland indicators.

The Rangeland Indicator Calculator provides a point-and-click interface to *terradactyl* and allows a user to produce any indicators which could be achieved through coding with the package, including the standard indicators reported by AIM and CEAP-GL. The user can currently calculate indicators from multiple data collection methods: Line-point intercept, Vegetation heights, Canopy gap, and Soil stability. The tool can both accept uploaded data and download data from the Landscape Data Commons, which contains data from a number of rangeland monitoring programs. Once indicators are calculated, they can be downloaded for use in other analysis and interpretation efforts. The Rangeland Indicator Calculator will empower land managers to have greater access to the kinds of information they need to support data-informed decision making.

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Forage Intake and Digesta Kinetics of Beef Cattle Differing in Feed efficiency While Grazing Idaho Rangelands

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Abstract

The objective was to determine if 2-yr old cows differing in residual feed intake (RFI) would differ in forage intake and digesta kinetics. Previously classified two-yr-old lactating Angus X Hereford cows (12 efficient; 12 inefficient) were given a one-time pulse dose of an alkane marker. Fecal samples were then collected repeatedly over 4 days in June and August. Daily digestible organic matter (DOM) was estimated from fecal near infrared spectroscopy. Data were analyzed fitting a non-linear digesta kinetics model to individual cows. A mixed model with RFI treatment, period, and their interaction as fixed effects, and cow within treatment as a repeated random effect, was then fitted to the combined kinetics data. There were no treatment differences ($P > 0.05$) between efficient and inefficient cows for the variables measured but period differences were present ($P < 0.05$). The marker total residence time in the gastrointestinal tract (RTG) was 39.2 and 39.1 ± 1.74 h for inefficient and efficient cows, respectively in June, and 43.9 and 43.9 ± 1.18 h for inefficient and efficient cows in August. Period RTG was 39.1 vs 43.9 ± 1.1 h for June vs August. Dry matter intake (DMI) in June for inefficient cows was 12.39 ± 0.89 kg and 11.24 ± 0.89 kg for efficient cows. August DMI was 13.18 and 12.64 ± 0.89 kg for inefficient and efficient cows, respectively. DOM was 58.9 vs 53.8 ± 0.36 % for June vs August. The compartmental mass of undigested dry matter (fill) was 5.5 vs 7.7 ± 0.36 kg for June vs August. Reliable estimates of intakes with the pulse dose procedure were obtained but RFI in a feedlot setting did not translate to a range setting.

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Open source satellite imagery and climate datasets predict forage quantity and quality of cool and warm season pastures

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Abstract

A major limitation in livestock grassland production systems is how to efficiently monitor forage resources. Effective monitoring plans inform appropriate stocking rates, enable greater resilience to climate variability, and promote healthy grasslands. Precision agricultural systems have ushered in a new era by incorporating big data analytics to integrate satellite imagery, climate data, and sensor technologies. The objective of this study was to develop data integration tools to test whether open-source climate, soils, and satellite imagery data can be used to predict forage quality and quantity for South Dakota rangelands. Growing season (June-October 2020 and April-October 2021), bi-monthly georeferenced forage samples were collected from Brookings and Cottonwood, SD. Forage samples were processed for biomass, crude protein (CP), neutral detergent fiber (NDF), and acid detergent fiber (ADF) to estimate forage quality and quantity through time. Data pipelines developed were used to automate the extraction of climate and satellite imagery metrics from Google Earth Engine (GEE) (e.g. growing degree days (GDD), spring precipitation, etc.) and compared with historic 40-year normals. Planet imagery NDVI time series data were used to construct general additive models to predict daily estimates of NDVI for individual sites. Random forest regression trees were used to predict forage quality and quantity across the two sites based on metrics derived from GEE and planet imagery. R2 values for predicted versus measured data in 2020 were 0.87 for biomass production, 0.67 for CP, 0.91 for NDF, and 0.90 for ADF. Results indicate that open-source data streams may be used to predict forage quality and quantity to better inform livestock management decisions. Better spatial and temporal information allows producers to capture forage resources at peak nutritional value, creating the opportunity for improved animal performance and natural resource management.

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Utilization of companion and cover crops during native range planting for rehabilitation of croplands

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Abstract

Current standards for range planting through the Cropland Reserve Program often limit stand success due to rigid guidelines not accounting for other environmental factors. Our objective was to improve stand establishment through the use of different seeding rates and cover/companion crops. Three locations in the Texas Southern and High Plains were selected to test species mixes over a three-year period to account for environmental variation. The Bamert, Gipson, and Pantex sites were located near the towns of Muleshoe, Cotton Center, and Panhandle, Texas, respectively. We planted the little barley (*Hordeum pusillum* (Nutt.) A. Love) and native mix in March 2022, and recorded cover by total vegetation, grasses, forbs, bare ground, litter, and individual species in June and August 2022. We collected biomass of grasses and forbs in August as well. We analyzed cover and biomass at each site separately. At the Bamert site, vegetative cover tended to increase from June to August, while litter tended to decrease. At the Gipson and Pantex sites, vegetative cover increased, and bare ground decreased. Litter cover decreased from June to August at Pantex as well. Forb and grass biomass was similar at the Bamert site in August. Forb biomass was greater than grass biomass at the Gipson site, but grass biomass was greater than forb biomass at the Pantex site. We will continue to monitor vegetation at the sites over the next couple of years. Results will guide future range planting guidelines in the region.

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Evaluating the level of availability and sensitivity in soil observations to support ecological site identification in the Western USA

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Abstract

Ecological site information is used to inform adaptive rangeland management strategies. The identification of ecological sites is based on soil properties (soil texture class, clay content, soil profile depth, etc.), landscape characteristics (elevation, slope aspect, landform, etc.), and plant communities which are critical co-variates in monitoring programs such as the Bureau of Land Management (BLM)'s Assessment, Inventory, and Monitoring (AIM) program. However, the extent to which ecological site information is available to AIM data collectors and the sensitivity of ecological site identification to the variability of soil observations remains undefined. To assist AIM data collectors in identifying an ecological site at monitoring plots, we evaluate both the level of availability of ecological site resources at local and national (Landscape Monitoring Framework – LMF) AIM monitoring plots and the variability of soil observations of collected data. We found that 31,854 monitoring plots (80% of all plots) contain ecological site identification. Of those plots, 24,546 plot locations (79% of plots with ascribed ecological sites) match the Major Land Resource Areas (MLRA) in which the ecological site concepts were originally developed. Data of 92,432 soil horizons from 29,072 plots were retrieved from terrestrial AIM databases. Soil texture classes are indicated in 90,814 soil horizons (98% of total soil horizons), whereas clay content is defined for 49,542 soil horizons (54% of total soil horizons). Leveraging this soil dataset, we present a summary of soil texture class, clay content, and soil pit depth in 14 states of the Western USA. We will use this analysis to identify opportunities for improving the access of ecological site information to monitoring crews and enhancing soil observation training to improve ecological site identification.

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Post-Fire Recovery and Cheatgrass Resistance of Perennial Grasses used for Restoration

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Abstract

Sagebrush communities in the Great Basin face a myriad of threats. Cheatgrass invasion has shortened fire return intervals and lowered species diversity. Additionally, climate models project warmer and drier conditions throughout much of the Great Basin, likely increasing drought, cheatgrass invasion, and wildfire. Intact stands of perennial grasses have been shown to limit cheatgrass invasion, and those that can establish and persist under harsh conditions are needed for restoration projects across the Great Basin. We evaluated 52 varieties of 13 perennial grass species commonly used in restoration settings for establishment, persistence, post-fire recovery, and cheatgrass resistance over six years at research plots in Ephraim, UT. Hierarchical cluster analyses showed that one group had significantly higher establishment and persistence and significantly lower frequency of cheatgrass than all other groups. This group contained all varieties of crested wheatgrass, Siberian wheatgrass, and intermediate wheatgrass, along with some varieties of basin wildrye, bluebunch wheatgrass, Salina wildrye, Snake River wheatgrass, and thickspike wheatgrass. Our results demonstrate that a diversity of plant materials can establish, persist, and resist cheatgrass through drought and fire.

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Thinning Dense Big Sagebrush to Replenish Herbaceous Understories: Part 2 Seedlings

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Abstract

Landscapes with Wyoming big sagebrush (Artemisia tridentata subsp. wyomingensis) make up ~25% of the sagebrush steppe. These rangelands are particularly prone to degradation, resulting in a depleted understory and dense sagebrush cover. Recovery of the perennial herbaceous understory is likely being limited by the dense sagebrush canopy and cannot be restored through simply reducing canopy density, active regeneration is needed (e.g. seeding). We designed an experiment to look at how a reduction in sagebrush cover and seeding perennial plants restores a degraded sagebrush site. In November 2021, we applied four rates of Tebuthiuron (0-kg ai/ha, 0.1-kg ai/ha, 0.23-kg ai/ha, 0.45-kg ai/ha) to reduce sagebrush cover. In March of 2022 we seeded three native perennial bunchgrass species and two native perennial forb species at a combined rate of 12.3-kg/ha per plot. We used our planting methods: hand broadcast, drill, a combination drill-broadcast (pulling every other seed tube), and control (not seeded) which were nested within each shrub reduction treatment. We hypothesized that 1) moderate shrub reduction promotes greater herbaceous seedling survival as it balances microclimate buffering and light availability; and 2) drill-broadcast seeding allows greater seed-to-soil contact at varying depths which should promote better germination and survival. Reducing sagebrush cover had no significant impact on seedling density (P =0.74). Of the five planted species Pseudoroegneria spicata (PSSP) and Elymus elymoides (ELEL) had the highest rates of emergence. We found drill-seeding produced the greatest density of seedlings (60.53±4.93 PSSP/m2 and 1.01±0.25 ELEL/m2), followed by drill-broadcast (35.03±3.02 PSSP/m2 and 0.69±0.18 ELEL/m2), with broadcast and no seeding producing similarly low densities of seedlings (1.08±0.22 PSSP/m2 and 0.0±0.0 ELEL/m2; 0.28±0.09 PSSP/m2 and 0.06±0.04 ELEL/m2 respectively. Monitoring will continue in proceeding years to observe seedling establishment with regard to sagebrush reduction.

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Adapting the APEX model for spatial variability in grazing lands of the western Great Plains

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Abstract

Modeling of rangeland forage production at the ranch scale is a tremendous challenge. Inherent variability in soils and vegetation is manifest in different plant communities which receive high spatial and temporal variation in amounts and distribution of precipitation. Changing climate adds additional complexity for ranchers to develop adaptive grazing management for their ranches. The Agricultural Policy/Environmental eXtender (APEX) model, originally developed to address multiple agricultural and environmental issues at the watershed scale, has been modified for use on rangelands with recent additions of rotational grazing components. Currently the APEX model operates at the pasture level for simulations, but ranchers have expressed a desire to incorporate within-pasture heterogeneity to reflect real-world conditions more accurately. To address this, our objective was to further modify APEX to simulate conditions at the level of ecological sites, so within pasture differences in soils and vegetation would be more accounted for in the model. To test the ability of APEX to accurately simulate forage production using ecological sites within pastures, we used data collected from the Long-Term Agroecosystem Research (LTAR) network Central Plains Experimental Range. Vegetation production data was collected during 2013-2022 from two ecological sites: Loamy Plains, dominated by warm-season perennial grasses with blue grama (*Bouteloua gracilis*) the dominant species, and Sandy Plains, dominated by cool-season perennial grasses with western wheatgrass (*Pascopryum smithii*) and needle-and-thread (*Hesperostipa comata*) the dominant species. With the modified APEX model using ecological sites, forage production was adequately simulated, including capturing the forage production variability associated with observed interannual variability in precipitation. Incorporating ecological sites into the model improved the utility for predicting forage production at the pasture level. This provides ranchers and land managers with an improved tool to incorporate into adaptive grazing management at the ranch level for scenario predictions in the face of a changing climate.

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Assessing vegetative state utilizing remotely sensed fractional cover and vegetation inventory data

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Abstract

State-and-Transition models are central to our current understandings of plant community dynamics in rangeland ecosystems. Response to disturbance, management options, and restoration pathways are well defined in a robust State-and-Transition model for a specific Ecological Site or Disturbance Response Group. The spatial application of these models has been challenging however, particularly at the vast scales often managed in rangeland science. Advances in remote sensing of vegetative functional group cover from satellite imagery have provided wall-to-wall information on vegetative cover, however, relating this data to ground-based vegetative cover assessment programs has been challenging. In this discussion we describe methods and resulting accuracy and information gained through objective assignment of vegetative state to ground-based vegetation cover data, and use of this information in the generation of vegetative state maps within discrete Disturbance Response Groups.

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Institutional interactions: How government programs and public land grazing permits influence adaptation on U.S. working rangelands

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Abstract

Ranchers are – and have always been – highly adaptive to social and environmental change. In the U.S., ranchers make adaptive decisions shaped not only by their own goals, but also within a nested institutional context that includes both formal and informal institutions. Understanding these cross-scale interactions is becoming increasingly important given the role ranchers play in stewarding both private and public rangelands in the U.S., particularly in light of drought and other climate-related concerns. This study examines how government programs and grazing permits administered by public lands agencies (i.e. Forest Service, Bureau of Land Management) influence Montana ranchers' ability to adapt to drought and other climate-related events. Results from a quantitative survey (n= 450) and in-depth interviews with 34 ranchers in Montana were used to understand ranchers' participation in a suite of government-administered programs and their perceptions of how these institutional arrangements enable or constrain their adaptive capacity and adaptive decision-making processes. Our findings suggest that government programs can both enable and constrain adaptation. Four key themes emerged: 1) inflexibilities in programs and permits limit adaptive management strategies that are tailored to local conditions; 2) slowness and inefficiency of government program processes limits timely management responses (to drought in particular); 3) relationships with local agency representatives influence the efficacy of program implementation on-the-ground, and; 4) ranchers' individual political ideologies and social values related to government involvement in land management influence participation in programs. Our results reflect the complex suite of cross-scale factors influencing ranchers' use of institutional arrangements to adapt to changing rangeland systems. We discuss the need for research and practice-oriented efforts that use participatory approaches for identifying ways in which government programs and permits can more effectively enable ranchers' ability to manage for and adapt to complex and changing conditions.

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Greater sage-grouse nest predation in a dynamic landscape: effects of western juniper expansion and removal, habitat use by predators, and nest-site selection

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Abstract

Expansion of western juniper (*Juniperus occidentalis*; hereafter juniper) into sagebrush (*Artemisia* spp.) steppe plant communities is a well-documented threat to greater sage-grouse (*Centrocercus urophasianus*; hereafter sage-grouse) populations in the Great Basin. Sage-grouse using habitats with juniper experience reduced nest survival, though the exact mechanisms driving this pattern remain unclear. Juniper trees potentially facilitate avian nest predators by providing extra perching opportunities. However, alternative hypotheses examining how mammalian mesopredators are associated with juniper cover have not been investigated. Risk to sage-grouse nests could be affected by broad-scale habitat use by predators and microhabitat nest site characteristics that affect the availability of visual and olfactory cues to predators. Removal of juniper from sagebrush communities is an increasingly common method of attempting to restore and improve sagebrush habitats for sage-grouse, therefore it is critical to understand how sage-grouse and their predators respond to these management efforts. We sought to establish how landscape factors, including juniper cover and habitat use by predators, in addition to microhabitat features at nest sites, influence nest predation rates for sage-grouse. We collected data in southwestern Idaho where a large-scale juniper removal project began in 2019. We evaluated broad-scale habitat characteristics including changing juniper cover and habitat use by predators of sage-grouse nests and collected data on both visual and olfactory concealment at nest sites (n=91) to determine effects on predation risk for sage-grouse nests. Results are preliminary and provided for timely best science.

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Reduction of Mechanisms Promoting Invasive Cool-Season Grass Increases Native Plant Diversity and Abundance

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Abstract

Invasive cool-season grasses reduce rangeland diversity and homogenize ecosystems, creating novel ecosystems. In the northern Great Plains, Kentucky bluegrass (hereafter: bluegrass) creates novel agro-ecosystems through the development of a pseudo-O horizon, or thatch, on top of existing mineral soil. Bluegrass thatch is not historically present in the northern Great Plains and alters water and nutrient cycling, soil microbiota, soil-surface microclimate, and reduces native forb and grass abundance. Conventional management of invasive cool-season grasses is often broad (i.e. fire, targeted grazing, or herbicide), focusing on reducing grass abundance, not the mechanisms that make bluegrass invasive. However, the effects of these all-purpose management strategies are often lost after a few years, demonstrating a need for new management that aims to reduce or eliminate the mechanisms that allow for the expansion of invasive cool-season grasses. One such strategy may be to target the mechanisms that promote bluegrass invasion, such as litter and thatch. To better understand the mechanisms behind bluegrass invasion, we monitored the effect of targeted litter and thatch removal on bluegrass abundance and native plant abundance and diversity in south-central North Dakota. We established 18 plots and removed litter and thatch from nine using a rotary brush attached to a skid-steer and measured species composition, litter, and thatch depth in each plot. Over three years, Simpson's diversity was consistently higher in removal plots, while bluegrass abundance was lower in non-removal plots. Additionally, native species abundance and richness were higher in removal plots than non-removal plots; suggesting that reducing bluegrass thatch and litter initially reduces bluegrass abundance, allowing for native species to increase in abundance over several years. These results also demonstrate that management practices aimed at controlling the mechanisms promoting invasive cool-season grasses, such as bluegrass, in rangelands are effective over several years.

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Targeted Grazing to Reduce Cheatgrass Abundance

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Abstract

Invasion by exotic annual grasses is one of the greatest threats to the survival of many sagebrush-steppe communities in the western U.S. today. One of the most widespread of these invaders is cheatgrass (Bromus tectorum L.). Targeted grazing has recently attracted attention as a method for cheatgrass management, primarily because of its low cost and high scalability. Current research suggests that exploiting the difference in growing seasons of annual and perennial grasses through grazing can be used to give perennial grasses a competitive advantage. The purpose of this study is to: 1) determine if fall, spring, or a combination of fall and spring grazing treatments can reduce cheatgrass biomass and cover without negatively impacting perennial bunchgrasses, and 2) investigate what role timing and amount of precipitation play in the effectiveness of dormant season grazing to reduce cheatgrass abundance on two sites in southern Idaho. We found no significant difference in perennial or annual grass cover or biomass between grazing treatments (fall, spring, spring and fall, and no graze). Perennial and annual grass cover and biomass, however, did significantly change from year to year across all treatments, suggesting a response to climate variability. Our results suggest that altering the timing of grazing alone may not be enough to reduce cheatgrass cover. We found very low levels of utilization (3-7%) in our treatment plots, suggesting that if cheatgrass reduction is the management objective, land managers should ensure that cheatgrass-invaded areas are being utilized at least at a moderate level (30-50%). In some situations, this may necessitate increasing stocking rates. Next steps in research should investigate whether higher utilization rates over longer periods of time are sufficient to reduce cheatgrass cover, and how plant communities respond to varying levels of utilization within a dormant season grazing system.

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Assessing the Drivers and Impacts of Invasive Cool-Season Grasses on Rangeland Plant Communities

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Abstract

Non-native plants invade and alter rangelands across the globe. Understanding the drivers behind these invasions and their impacts on native plants is critical in controlling and mitigating invasive species. Rangelands in the northern Great Plains are being converted into novel ecosystems by invasive grasses, especially Kentucky bluegrass (Poa pratensis) and smooth brome (Bromus inermis; hereafter ‘bluegrass’ and ‘brome’, respectively). Both invade rangelands and form dense litter layers, with bluegrass litter specifically leading to the formation of thatch, a unique pseudo-soil layer. To understand and quantify the impacts of these invasive grasses on rangeland plant communities, we assessed how grazing influenced bluegrass and brome abundance. Additionally, we examined how brome and bluegrass directly influenced rangeland plant communities through competition and indirectly through litter and thatch accumulation using Structural Equation Modeling (SEM). We sampled plant community composition and abundance of thatch and litter in 12 pastures managed with either season-long grazing, patch-burn grazing, or heterogeneity-based rotational grazing. Using SEM, we found that grazing negatively impacted thatch and litter abundance and all grass abundance (including bluegrass and brome) and positively influenced native forb and legume abundance. Brome negatively impacted litter and thatch accumulation and native forb and grass abundance. Bluegrass positively influenced litter abundance and negatively impacted all native plant functional groups except shrubs. Litter abundance also positively influenced thatch and non-native grass and legume abundance while negatively influencing all native species. Finally, thatch abundance negatively influenced native grass and forb abundance and non-native legume abundance. These findings demonstrate that invasive grass litter has a stronger, more pervasive, impact on rangeland plant communities than thatch. However, novel thatch accumulation furthers the harmful impacts of invasive plants on many native rangeland plants. This suggests that future management of invaded rangelands should favor methods to reduce invasive grass litter and thatch.

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Arriving at a natural solution: Bundling credits to access rangeland carbon credits

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Abstract

Avoided conversion of grasslands represents the primary natural climate solution relevant to rangeland systems. Credits developed through avoided conversion projects can be sold to support rangeland-based livelihoods and help mitigate climate change. The presentation examines how landowners in rangeland systems can access carbon markets through participation in avoided conversion of grassland projects. Further, the presentation discusses how landowners and project developers can gain economic efficiencies through aggregation, or the pooling of individual carbon projects. We argue that aggregation can lower barriers to entry for the voluntary carbon credit market and allow for greater landowner participation. This presentation is a follow-up on an article by the same name published in *Rangelands.* The article is a result of conversations with practitioners around the west, including land trusts, carbon credit project developers, carbon credit project aggregators, and voluntary carbon market registries. As more organizations are committing to reducing or offsetting their carbon footprint, the demand for durable carbon credits will continue to rise. Land stewards and all who work to support them should be prepared to take advantage of the stream of revenue these credits may provide. Aggregating carbon credits creates economic efficiencies that may open the market to landowners and projects which would otherwise be infeasible.

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Quantification of seasonal browse on Curl-Leaf Mountain Mahogany Stands in the Great Basin

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Abstract

Curl-leaf mountain mahogany (Cercocarpus ledifolius), a widespread species in Nevada, provides critical winter habitat for mule deer (Odocoileus hemionus) populations and serves to stabilize soil and fix nitrogen on sites where it is common. This evergreen, shrub species has also been commonly used to estimate fire return intervals in shrub steppe ecosystems. Despite its ecosystem value and management utility, there remain several understudied aspects of this species in the Great Basin region. One of these is its response following the removal of singleleaf pinyon (Pinus monophyla) and Utah juniper (Juniperus osteosperma) in ecosystems where these trees have expanded, and the impact that this could have on the availability and preference of these plants to browsing ungulates. Five mahogany stands in the Desatoya mountains were measured for seasonal browse in winter and summer months. The stands are primarily browsed by Mule Deer (Odocoileus hemionus), Pronghorn antelope (Antilocapra americana) and Wild horses (Equus ferus) in the winter months, and are also grazed by cattle (Bos taurus) in the summer months. Browse extent of Mahogany stands were paired with game camera images of species for an assessment of ungulate browse rates and extent in thinned and un-thinned stands of mahogany.

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Competing Conservation-Mitigation Paradigms on California Grazinglands

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Abstract

Human population growth and the development of supporting infrastructure are only expected to increase over the next mid-century. In California, the interface between urban-agriculture-wild landscapes will likely see most of this development activity with some estimates of the impact of conversion of pasturelands forecasted as high as 10,000 km2 by mid-century. The eventual conversion of these landscapes and loss of critical and protected habitats and ecosystem services must be mitigated. In this study we explore two competing conservation-mitigation paradigms. The agricultural-conservation tradeoff paradigm is underpinned by the assumption that in order to conserve-enhance desired ecological traits of a site; goal setting, land use decision-making, and management implementation must shift to the authority of new “expert” conservation professionals and agricultural production becomes secondary and/or eliminated. The agriculture-conservation synergy paradigm recognizes that desired ecological traits already exist on the site and current goal setting, agricultural based land use decision making, and management implementation are at least compatible with conservation and potentially required for the existence of desired ecological traits. The goal of this study is to use the Little Lake Valley (LLV) Mitigation Management Plan (MMP) as a case study and lens to assess the social-economic-ecological ramifications of following the tradeoff versus the synergy paradigms. This tradeoff based MMP has been unfolding over the past 10 years. We used this opportunity to examine the extent to which these paradigms lead to different goal sets, decision-making processes, management practices and strategies, and the social and economic costs associated with transitioning to a tradeoff conservation management strategy versus maintaining an in-place synergy-based strategy. Furthermore, we use these findings to discuss the LLV MMP in the context of the existing scientific literature and alternative conservation strategies.

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Predicting bunchgrass mortality during a fire event in Wyoming big sagebrush communities using remote sensing

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Abstract

In Wyoming big sagebrush (Artemisia tridentata Nutt. ssp. wyomingensis) plant communities with significant presence of annual grasses, post-fire efforts to reestablish perennial grasses generally fail, despite massive capital investment. Given the risk of wildfire in any given year throughout these plant communities, reducing annual grass expansion into relatively intact communities is paramount. This involves managing these communities for increased resilience to fire, possibly by prioritizing perennial grass survival through preemptive modification of shrub fuel structure. Preliminary data suggest that shrub fuel loading increases heat characteristics (i.e, heat loads, maximum temperature, and duration of elevated temperature) impacting perennial bunchgrass mortality. However, the data also suggest that as the distance from the shrub canopy increases, bunchgrass mortality decreases in association with reduced heat. The objective of this study is to use high resolution remotely-sensed imagery and ground-based measurements to model the relationship between shrub fuel loads and increased probability of fire-induced bunchgrass mortality. High resolution imagery was acquired on sites across Utah along with ground measurements of shrub and perennial grass cover in April 2022. An object-based image analysis was used to classify imagery using eCognition software. Non-parametric multiplicative regression analysis (e.g. random forest) will be used to create predictive models for fire-induced bunchgrass mortality. We anticipate that information generated by this project will directly assist land managers in 1) identifying conservation priorities in large landscapes, and 2) modifying shrub fuel loading in Wyoming big sagebrush communities to reduce fire-induced perennial bunchgrass mortality.

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Collaborating Across Borders for Rangeland Benefits

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Abstract

The Southeast Oregon Wildfire Resilience project is a $5 million project for wildfire resilience on 70,000 acres in the Stinkingwater Mountains. Annual grass herbicide treatment, native seed collection and drilling, and selected juniper treatments increased wildfire resilience simultaneously accomplishing habitat enhancements, range improvements, and restoration activities in Southeast Oregon. Projects were selected by overlaying multiple GIS layers using the SageCon Landscape Planning Tool and personal knowledge of the areas. This project was created and submitted in two months with eight partners doing land management on federal, tribal, state, and private lands across two BLM jurisdictions and in two Oregon counties to treat over 70,000 acres of rangeland.

The hard conversations that built trust among diverse partners began years before when they started meeting at the Harney County Wildfire Collaborative allowed for this large-scale project to be submitted in two months. Even with the long-time trust and collaboration this project still had its challenges and successes. Coordination of projects on a large landscape in a short amount of time, application window of funding, rising costs, and partners adjusting their proposed projects to fit budgets were some of the main challenges. Successfully bringing together multiple diverse partners to align projects strategically on a large landscape to plan for wildfire resilience, a rangeland project being funded in a primarily forest-focused state legislation funding and this project being leveraged to increase restoration activities and wildfire preparedness in the Stinkingwater Mountains were some of the successes. Lastly, the lessons learned are the benefit of private-state-public land managers coordinating project areas multiple years ahead to creating strong partnerships to support each other. Clear and consistent communication through documenting landmark decisions as well as coming together often to stay on track.

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Long-term effects of stocking rate, year, and weather on honey mesquite canopy cover and density

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Abstract

Abiotic (precipitation, temperature) and biotic (grazing) factors are thought to be important drivers of undesirable woody shrub encroachment in arid rangelands. Woody encroachment has pervaded global rangelands over the past century, but the relative impacts of either grazing or climate are still not fully understood. We sought to evaluate the long-term (25 years; 1995-2019) effects of stocking rate (light: 25-30% and conservative: 35-40%; key forage species use rate), year, and the interaction of stocking rate by year to explore the impacts of grazing and annual weather fluctuations on percent cover and density of honey mesquite (*Prosopis glandulosa*), a native but invasive shrub, at the Chihuahuan Desert Rangeland Research Center (CDRRC) in southern New Mexico. Precipitation data were collected continuously at the CDRRC; temperature data were collected at the neighboring USDA-ARS Jornada Experimental Range. Drought occurred in 12 of 25 study years and mean ambient summer temperature increased from 15.1 ± 0.15 to 15.4 ± 0.27°C between the first and last 12 years of the study period. We found that stocking rate and the interaction of stocking rate by year had no effect on mesquite percent cover or density (% cover: $P = 0.70$; density: $P = 0.10$), although year had a significant effect (% cover: $P < 0.01$; density: $P < 0.01$). Mesquite canopy cover increased by 3% from 3.8 to 7.1% cover and mesquite density increased by 175% ($P < 0.01$) from 284 ± 53 plants*ha^{-1} to 782.08 ± 35 plants*ha^{-1} between the last vs first three years of the study. Our preliminary results support a growing body of literature that suggests the overriding effects of climate (increased temperatures and prolonged droughts) will continue to drive undesirable shrub encroachment on Chihuahuan Desert rangelands even when animal stocking rates are kept at historically sustainable levels.

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Demographic rates of invasive perennial bunchgrass grass buffelgrass (*Pennisetum ciliare*) vary with topography

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Abstract

Understanding drivers of population dynamics of invasive species is vital for explaining patterns of expansion and identifying areas at risk of novel invasions. Environmental factors such as climate are known to affect plant demography over large scales, but the effects of small-scale variation in environmental factors on plant demography warrant further study. Small-scale variation in topography influences microclimate conditions, which can in turn affect demographic rates of plants. We investigated how demography of the invasive perennial bunchgrass buffelgrass (*Pennisetum ciliare*) varies with local-scale topography, buffelgrass density, and native plant cover. We established 27 transects on north-, south-, east-, and west-facing hillsides in Sonoran Desert habitat in Tucson, AZ. We tracked the growth, reproductive output, and survival of up to thirty buffelgrass individuals in each transect during the monsoon seasons of 2020-2022.We modeled the effects of physical topographic characteristics (slope aspect and grade), buffelgrass density, and native plant cover on buffelgrass demographic rates. We found that local scale topography had significant effects on buffelgrass demographic rates. Buffelgrass plants produced the most reproductive culms on south-facing slopes and produced the fewest reproductive culms on north-facing slopes. Grade amplified the effects of slope aspect, with plants on steeper slopes producing fewer reproductive culms than plants on shallower slopes. Buffelgrass plants on east-facing slopes suffered the highest mortality rates. The observed effects of local scale topography on buffelgrass demography help explain large scale patterns of buffelgrass distribution in Sonoran Desert scrub habitat. Buffelgrass invasion poses a risk to native Sonoran Desert plant communities via competition and increasing the risk of wildfire. Our results indicate that local scale topography may be a powerful predictor in distribution and spread of buffelgrass and can help identify suitable habitats at risk of invasion by buffelgrass.

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Assessing grazing behavior of heritage, hybrid, and conventional cattle breeds in response to climate change

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Abstract

Evidence suggests that heritage and hybrid beef cattle breeds exhibit more flexible foraging behaviors compared to highly selected conventional breeds. We hypothesize that these behaviors could be capitalized upon to support sustainability outcomes, such as biodiversity or climate change adaptation. We conducted a systematic search of studies that compared beef cattle breeds for behavioral traits and found 54 studies conducted since 1966 located in 9 of the 14 major terrestrial biomes, with 60 beef or dual-purpose breeds represented. We created a typology of the studies with respect to decade, continent, breed provenance (Continental, Criollo, Hybrid, *B*. *indicus*, Mediterranean, Sanga, British Isles), breed selection intensity (heritage [limited selection pressure], conventional [high selection pressure], hybrid [moderate selection pressure]), biome, study intent, and whether breeds met desired outcomes described by the study authors. Most studies (69%) were conducted in arid rangeland settings in developed nations where researchers sought to minimize the negative environmental impacts of beef production. In comparisons of grazing behavior of heritage versus conventional types (n=25 studies), and hybrid versus conventional types (n=18 studies), heritage and hybrid cattle displayed more adapted traits (e.g., improved foraging distribution) in 88% and 78% of the studies, respectively. No differences were found in grazing behaviors in most studies in which heritage breeds were compared to other heritage breeds or conventional with conventional breeds (n=6 and 15 studies, respectively). In the subset of studies coded with the intent of “foraging behavior,” heritage types traveled faster across a range of pasture sizes, which could indicate a capacity to seek high-quality nutrients while reducing trampling or overgrazing. Overall, our review suggests that breeds that have undergone moderate – low selection pressure display grazing behaviors that demonstrate adaptation to their respective native environments and may help producers meet production goals in similar environments in the face of a changing climate.

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Remote Sensing products as demographic data: scaling traditional demographic approaches to forecast pinyon-juniper woodland expansion and contraction in the Great Basin

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Abstract

Pinyon-Juniper (P-J) woodlands cover 70,000 square miles of the western US—sequestering carbon and providing critical wildlife habitat. In the Great Basin, in particular, the vulnerable Pinyon Jay relies on intact and healthy P-J woodlands. Due to a combination of changing land use and climate, P-J woodlands have expanded over the last century. This rapid expansion event has presented management concerns—encroachment into sagebrush-steppe, interruption of forage production, increased water-stress, and fire risk. However, evidence also suggests increased vulnerability and declining growth rates of P-J woodlands, likely due to drought in recent years. Therefore, landscape and regional-scale forecasts of future expansions or contractions of P-J woodlands could aid management decisions. Both *Juniperus occidentalis* and *Pinus monophylla* are dominant tree species in the Great Basin, forming nearly single species stands across central Oregon and western Nevada, respectively. Demographic studies of single species provide mechanistic understandings for the persistence and viability of woodland populations. However, traditional approaches are time intensive. Earth observatory programs provide high spatial and temporal resolution imagery. In some cases, these programs provide sixty plus years of monitoring data. The overarching objective of this project is to leverage historical aerial imagery and satellite-derived land cover products to quantify range-wide shifts in species abundance. Using spatiotemporal demographic approaches, we can: 1) forecast range expansion and/or contraction given future climate projections 2) build models to assess demographic performance in response to temporal and spatial variation in climate. Preliminary analyses show great promise for using remotely sensed data products to understand and forecast changes in the distribution and abundance of P-J woodland species. Such spatially explicit region wide forecasts will highlight areas where management practices maybe desirable or where conservation of declining woodlands may be necessary.

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Changes in Campos grassland sward structure under two herbage allowances

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Abstract

A long-term experiment was used to study the effect of two herbage allowances (HA) (6 and 9 Kg DM/Kg LW for Moderate [Mo] and High [Hi] respectively, that varied seasonally: Hi 6 during winter and 10 DM/Kg LW the rest of the year and Mo 6 DM/Kg LW throughout the year) on the temporal evolution of the Campos grassland sward structure throughout a year. The % of short patches (SP), tall patches (TP), bare soil (BS), and feces were registered in 350 permanent quadrats of 1x1 m every 45 days. For each patch type % of forbs, shrubs and green mass (GM) and canopy height were registered. Repeated measures were used to study the HA*time interaction. Hi had greater herbage mass (1283 ± 355 vs 1933 ± 448 kgDM/ha) and height (3,7 ± 0,75 vs 5,2 ± 1,16 cm) compared to Mo and resulted in greaterTP, TPheight, and lower BS. The short patches did not differ between treatments in any response variables. Through the seasons were found differences in TP height, SP height , GM in tall and short patches. The TP and TPheight increased during the growing season (7 vs 11.1 ± 3.9%; 7 vs 11.5 ± 0.9 cm) while shrubs proportion were reduced (45.4% vs 35.5% ± 3.6).The percentage of GM in TP stayed stable (45± 4.2 %) when TP increase the amount of GM increase. After the growing season the GMtall patches go down. Hi resulted in an increase in herbage mass in area and height of tall patches that after the growing season reduces his green mass, without differences in short patches. These results contribute to explaining the affects of HA on the spatiotemporal dynamics of herbage growth and intake as well as ecosystem services.

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Vegetation diversity, productivity, and soil dynamics in reclaimed grassland

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Abstract

Vegetation dynamics in reclaimed grassland are unique compared to natural grassland. Utilizing reclaimed grassland for grazing purposes is challenging as its resilience is compromised due to disturbances. The study's objective was to determine the effects of regenerative grazing on productivity and vegetation dynamics of reclaimed grassland in Shirley Basin Wyoming. Soil and vegetation samples were collected in 2021 and 2022 from three reclaimed uranium mine sites and two natural grasslands under no, short-term, and long-term grazing scenarios. Results showed that the vegetation biodiversity index was not different between natural and reclaimed sites in all grazing scenarios indicating quantitative biodiversity was similar. Vegetation composition was alike in natural grasslands but varied among the reclaimed sites indicating qualitative differences among the sites. Reclaimed sites had higher dry matter productivity (1370 kg ha-1) compared to natural grasslands (537 kg ha-1). Natural grasslands had the highest total soil carbon (19.6 g kg-1) at 0-15 cm depth while no difference among sites was observed at 15-30 cm (15.3 g kg-1) and 30-45 cm (21.9 g kg-1) depths. Site history affected vegetation diversity, biomass production, and soil carbon content instead of grazing scenarios. Overall, the preliminary results showed that reclaimed sites could provide enough forage for livestock grazing, however, it will require a longer time to attain an ecosystem similar to natural grasslands.

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Comparing Unmanned Aerial Vehicle (UAV)-Collected and Field Observer-Collected Floral Cover Estimates for Rangeland Forb Species

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Abstract

Floral resource estimates can be used as a proxy for estimating site quality for pollinators. Floral estimates are traditionally collected with field observers, however, logistical challenges associated with this method warrant a need for an alternative technique. Remote sensing with unmanned aerial vehicles (UAVs) is a relatively new technique for collecting ecological data, and may be a solution for collecting accurate floral resource data without the challenges associated with traditional methods. Thus far, collecting floral resource data with UAVs has received limited exploration, therefore, we compared the accuracy of floral cover estimates collected with UAV and field observer methods. Our objectives were to 1) assess UAV accuracy for classifying floral abundance of target species, 2) quantify the difference between UAV-collected and observer-collected floral estimates, and 3) assess the influence of floral characteristics on UAV classification accuracies. We simultaneously collected UAV imagery and field observer floral cover estimates across multiple 20 x 20 ft plots within four sites between mid-June and late-July of 2021. We classified UAV imagery in ArcGIS Pro with a supervised, object-based classification and the Maximum Likelihood algorithm, and assessed the accuracy of classified images. We will use a t-test to quantify differences in cover estimates between collection methods and test for accuracy differences in species with an ANOVA and pair-wise comparisons. We are still analyzing our results, but our expectations are that UAV-collected floral estimates will be more accurate than observer-collected cover data, and that UAV accuracy will differ between species due to differences in species characteristics. In our analysis thus far, UAV-collected floral estimates have been consistently lower than field observer-collected values, suggesting that traditional methods may overestimate floral resource cover. This work will contribute to the development of rapid and accurate methods for quantifying pollinator resource bases for management, monitoring, and research applications.

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Plant community dynamics following herbicide application across a mesquite encroachment gradient

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Abstract

Woody species such as Honey mesquite (*Prosopis glandulosa* Torr.) have progressively encroached into historically grass-dominated ecosystems across much of the southwestern United States, aided by factors including extensive livestock grazing and drought. The transition to mesquite shrubland reduces the abundance of native grass and forb species, increases soil erosion and redistribution of ecosystem resources, and ultimately decreases the ecological and economic services provided by these lands. Though mesquite may be effectively removed or reduced by control measures, the recovery of desirable herbaceous plant species could be dependent on encroachment severity prior to management, and after a threshold is crossed, difficult to achieve even with active intervention. To examine how initial mesquite encroachment severity influences plant community dynamics following herbicide treatment, we established twenty sets of paired herbicide-treated and untreated 5-ha plots across a gradient of relatively low to high mesquite encroachment on the Jornada Experimental Range in southern New Mexico. Annual ground-based vegetation surveys and drone imagery data were collected prior to (2020) and immediately following (2021) herbicide application. Changes in plant community composition between pre- and immediately post-treatment years were primarily characterized by increasing annual grass and forb cover, and to a lesser degree perennial forb cover, following a favorable 2021 monsoon season. Perennial grass and shrub cover remained similar between years. One year post-application in 2022, mesquite morality surveys were conducted alongside ongoing annual data collection, and Connectivity Modifiers (ConMods) were installed to examine the effect of reducing bare ground connectivity in conjunction with mesquite control to aid herbaceous plant recovery. Collectively, we expect data from this project will help landowners and managers decide when best to invest in mesquite management and what plant community recovery (or lack thereof) may look like post-treatment given initial mesquite encroachment severity.

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New tools for fire management using ecological site groups, monitoring data, and machine learning

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Abstract

Wildfire drivers in the US are diverse and vary widely across landscapes. Fire management strategies are similarly diverse; they often depend both on immediate goals, such as reducing risk to infrastructure and natural resources, as well as long-term goals to improve ecosystem services and land conservation. National maps for wildfire management are often unsuitable for drylands, where risk indicators depend strongly on local ecological context, necessitating higher resolution understanding and tools. Our study aims to inform fire and fuel management options in the more fire-prone savannahs and woodlands of the western US, with a focus on the Upper Colorado River Basin. Our goal is to integrate Ecological Site Groups (ESGs) with probabilistic state-and-transition models (STMs), new remote sensing products, and machine learning to provide a more systematic integration of fire and fuels distribution with characterized ecological context. This approach will increase the utility of spatial decision tools for fire and fuel management and will apply to other landscapes. One critical component of this project is using a co-production framework, where scientists and stakeholders collaborate to ensure utility, robustness, and reproducibility of mapped products to end-users and wildfire science. Using a cross-agency steering committee we will: (1) map current conditions using existing agency monitoring data and supplemental data collections; (2) map attainable desired conditions using STMs and predictive mapping approaches; and (3) map departure from desired conditions and identify challenges to achieving these desired conditions. Here we present developed maps of current conditions in target ESGs concerning fire and fuels, knowledge gaps identified at co-production workshops, and the supplemental field sampling needed to fill key gaps. We also present how this project with the co-production framework will complete maps of desired and departure from desired conditions based on end-user and scientific metrics of wildfire risk and ecosystem structure and function.

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An Examination of Cotton Residue as a Potential Feed Source in the Texas Panhandle

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Abstract

The Texas Panhandle is one of the most agriculturally intensive landscapes in the world and is responsible for producing billions of dollars in cotton annually. From a rangeland perspective, the region is traditionally composed of warm season grasses that taper out in vegetative productivity and nutritional value at a similar time frame to that of cotton harvest. This provides the opportunity to graze cotton residue in the late fall and winter as a supplement to grazing lands. While studies in the eastern half of the United States have identified possibilities of grazing cotton residue, differences in both basic machinery from a harvesting perspective and the size of plants provide adequate evidence to suggest that residue from the Texas panhandle may differ in quantity and quality, implying a need for further analysis in the western region. For this study, we aim to identify if residue from subsurface drip irrigation cotton crop fields will provide an acceptable amount of biomass and adequate nutrition to meet the nutrient requirements of mature, gestating cows. To achieve this, we will run transects and collect biomass measurements at recently harvested cotton fields within the northern panhandle of Texas. Collected residue will be separated into stalk, seed, lint, and leaf, and then analyzed for protein, fiber, total digestible nutrients, and in vitro digestibility. Due to data collection occurring later this fall, results have not yet been generated, but will be accessible for the annual convention in February.

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There’s an App for That: Development of a Decision Support Tool to Assist Rangeland Managers with the Control of Twolined Spittlebug in Hawaii

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Abstract

Twolined spittlebug (TLSB), *Prosapia bicincta*, was detected in Hawaii in 2016 where it had damaged over 800 ha of rangeland. Research revealed that TLSB expanded its range to over 71,225 ha in approximately eight generations. In highly infested areas, TLSB resulted in nearly 100% die back of key range grasses including Kikuyu (*Pennisetum clandestinum*) and pangola (*Digitaria eriantha*) grasses when nymph densities exceeded 50/m^2. The loss of these important forages provided entry for the establishment of invasive plants including Pamakani (*Eupatorium adenophorum*), wild blackberry (*Rubus* spp.), and fireweed (*Senecio madagascariensis*) among others. These losses forced livestock producers to reduce stocking rates resulting in significant economic losses. Work on a smartphone application to identify, report, and facilitate management of the TLSB started in 2020. The app has four main features. An information guide that provides an overview of TLSB biology and ecology. Next, the app provides a tool to help users identify TLSB in the field and distinguish it from other, non-pest species. A third tool allows users to report sightings of TLSB. Reports include a geo-referenced picture and basic details about the habitat and geographical location of the pest. The reported data is then captured in a database and displayed on a web-based mapping tool. Users have the option to enter data on TLSB population density and provide estimates on spatial extent and observed damage in their report. Data on TLSB populations is determined by following sampling protocols provided in the fourth tool. This tool allows users to determine the size of the TLSB population, and then, based on the potential damage threshold calculated, select from a series of integrated pest management decisions. It is anticipated that this app will facilitate tracking and documenting the spread of the pest and lead to better pest management decisions for rangeland managers.

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Prescribed Fire for Restoration of California Grasslands

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Abstract

California cismontane grasslands are floristically and ecologically unique and biologically and economically important, but highly altered by human activities. Non-native grasses and/or forbs have partially to entirely displaced native species in the majority of these grasslands. In the last four decades, prescribed fire and/or grazing have been used at these sites to increase native plant abundance with a varying range of success. Because there is wide variation in grassland communities, degradation level, and burn conditions, as well as regional and annual climate variation, a quantitative review was needed to interpret the variation in treatment success and determine when and where burning was most beneficial. Meta-analysis was used to synthesize the results of over two dozen prescribed fire and prescribed fire with post-burn livestock grazing studies. We assessed general effects of fire and interactions with livestock grazing, including the magnitude, variability, and longevity of effects on plant life history-origin groups (native forbs, exotic forbs, exotic annual grasses, and native perennial grasses). We tested the general hypotheses that these groups respond to fire and fire and grazing combinations differentially. In general, fire resulted in short-term and consistent increases in native and exotic forbs, and temporary reduction in exotic grasses. Exotic forbs benefited most from post-burn grazing, although not greatly in magnitude. Native perennial grasses rarely, if ever, increased after fire or fire and grazing combinations, although data is limiting. In addition, the effect of fire on plant life history-origin groups is influenced by different drivers. Native forbs were significantly influenced by burn season, but evidence for climate effects is lacking. In contrast, strong evidence indicates non-native forbs and grasses are significantly influenced by treatment type and precipitation interactions. These results help contextualize prescribed burning results and are informative for restoration planning.

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USING GENETIC SEQUENCING OF FECAL SAMPLES TO UNDERSTAND DIETARY AND MICROBIAL DIFFERENCES IN FERAL HORSES AMONG BLM HERD MANAGEMENT AREAS

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Abstract

Burgeoning feral horse (Equus ferus caballus) populations pose a critical management challenge across 10 western states, affecting rangeland integrity and co-occurring species. The purpose of our research was to use fecal samples to evaluate differences in diet and gut microbial communities in feral horses managed in herd management areas (HMAs) by the USDA-Bureau of Land Management (BLM) in the western United States. We used amplicon sequencing to understand the role feral horses serve as large herbivores in the ecosystems they inhabit. Quantifying which plant groups feral horses are consuming in summer and winter and variable environments is important to assist managers in balancing horse use with wild and domestic herbivores sharing common rangelands. We used the chloroplast trnL intron to identify plant composition and the 16S rRNA gene to determine gut bacterial composition across a gradient of herbaceous availability in samples from16 BLM HMAs across 7 western states. We collected 490 fecal samples in summer 2020 and winter 2020/2021. We compiled information for plant species present in each HMA to confirm key species were available in the database for downstream comparison and when missing, obtained voucher plant samples from the Rocky Mountain Herbarium. Because we collected our samples with the same methods and during the same year, our study was advantageous to previous comparisons, supporting direct dietary comparisons among horses in different areas. We compared bacterial composition across HMAs to determine differences in the gut microbiome of feral horses in different environments. We compared variation in diet to variation in microbiome to identify a possible mechanism for how horses exhibit population growth in varying environments in the West. Our research shows the value of interdisciplinary collaborations to integrate cutting-edge technologies into our understanding of rangeland management.

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Avian Nesting Communities and Success in a Heterogeneity-based Rotational Grazing System

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Abstract

Traditional grazing management focuses on maximizing cattle production through uniform utilization of forage resulting in reduced vegetation structure and composition. This homogenization decreases avian niche diversity, contributing to ongoing declines in grassland bird communities. Patch-burn grazing can restore vegetation heterogeneity, but a cultural aversion to fire warrants alternative heterogeneity-based management. In 2018, we established a modified rotational grazing system which varies grazing intensity to create heterogeneity across paddocks. Our treatment structure includes four replicates, each split into four paddocks based on percent utilization: heavy (60+%), full (40-60%), moderate (20-40%), and rested (0%). We assessed the efficacy of this system to achieve heterogeneity and the subsequent impacts on grassland birds by quantifying effects of grazing intensity on 1) vegetation structure, 2) avian community composition, and 3) nest success. We conducted vegetation sampling to quantify vegetation structure and rope dragging to locate nests within paddocks. Nests were subsequently monitored to determine fate. We incorporated vegetation structure and composition measurements taken at each nest into a hierarchical modeling scheme using RMark to assess nest success. We found that modifying grazing intensity within a pasture creates heterogeneity ranging from tall and dense rested paddocks to short and sparse heavy-use paddocks. Grazing intensity did not directly alter avian nesting community composition in either 2021 or 2022 ($p = 0.06, 0.099$, respectively). However, nest success of grassland birds may be indirectly impacted by grazing through the manipulation of key structural components associated with nest success including litter depth and vegetation height. Responses to these structural components were species specific, reflecting the importance of heterogeneity when managing for diverse grassland birds. Our results demonstrate the potential for an alternative management practice that increases heterogeneity and can inform grassland bird management. When fire cannot be applied, this management practice can incorporate conservation needs into a livestock production system.

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Soil seed bank and aboveground vegetation community dynamics across a shrub encroachment gradient in the Northern Chihuahuan Desert, U.S

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Abstract

Soil seed banks – living seeds in the soil profile and on the soil surface – represent primary sources of regenerative potential and buffering capacity against disturbance in dryland ecosystems. Soil seed banks may degrade during aboveground vegetation state transitions, but may assist with plant community recovery if management actions are taken prior to alternate state transition. To examine how the seed bank may impact aboveground vegetation dynamics, we established 120 pairs of shrub-island and interspace soil seed bank sampling locations (240 total sample locations) across twenty 5-ha plots on sandy and shallow-sandy ecological sites on the Jornada Experimental Range. These plots are distributed across a gradient of shrub encroachment including relatively low encroached reference state black grama (*Bouteloua eriopoda* (Torr.) Torr.) grasslands to alternate state honey mesquite (*Prosopis glandulosa* Torr.) shrublands. Soil seed bank samples were collected in fall 2020 and 2021, and underwent greenhouse emergence trials to quantify the soil seed bank composition during 2021 and 2022, respectively. Aboveground vegetation functional group data were collected concurrently with the seed bank samples, characterizing the morphology of the sampled shrub-islands and the vegetation community of the sampled interspaces. Seed bank samples and aboveground vegetation data were collected during fall 2022, as well. Here we compare two years of soil seed bank emergence data (2020 & 2021) and three years of aboveground vegetation data (2020-2022) to understand their spatio-temporal dynamics. Across the gradient, for both years, the soil seed banks of interspaces and shrub-islands were dominated by annual forbs, which were able to emerge and establish in the aboveground vegetation during 2021 & 2022. As shrub encroachment increased and crossed the state transition to a mesquite shrubland, seeds of all functional groups became concentrated under shrub-island canopies and were depleted from interspaces, limiting the establishment of perennial herbaceous vegetation.

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Soil Moisture, Vegetation, and Shallow Groundwater Level Variability in a Rangeland Setting in the Chihuahuan Desert, Northern Mexico

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Abstract

The objectives of this study were to 1) characterize precipitation-soil moisture-shallow groundwater relationships following restoration in a 500-ha rangeland watershed in the Chihuahuan Desert in northern Mexico and 2) assess vegetation interannual variability before and after restoration. Various conservation practices, including land imprinting, grade control structures, small basins, and planting of native shrubland species (i.e., *Atriplex canescens* and *Prosopis glandulosa*) were conducted between 2012 and 2015 in a multiple-use (wildlife habitat and livestock) ranch. The average annual precipitation in the region is 219 mm. Since 2014, the study site has been gradually instrumented to monitor several hydrologic variables, including rainfall, soil moisture, and shallow groundwater fluctuations. The soil moisture sensors at 0.2 m depth responded relatively rapidly to specific precipitation events, particularly during the summer monsoon season. The soil moisture content at 0.8 m depth was only significant following rainfall events greater than 48 mm h-1. An increase in soil moisture level observed during the winter season in all sensors was attributed to decreased plant water uptake during dormancy. Recharge of the shallow (~ 20 m) aquifer generally occurred during fall and winter, with seasonal peak water table rises of up to 0.94 m. Changes in vegetation cover were evaluated using Normalized Difference Vegetation Index (NDVI) values calculated from Landsat 8 images. Correlation analyses showed a strong positive and significant Pearson correlation coefficient between annual precipitation and maximum annual NDVI (R^2=0.916, P=0.029) and between maximum annual NDVI and seasonal aquifer response (R^2=0.96, P=0.009). Annual precipitation and aquifer response strongly correlated (R^2=0.915, P=0.029). A regression analysis to compare accumulated monthly precipitation and groundwater level variability showed a rise in groundwater level after accumulated precipitation of 100 mm (R^2=0.72). This ongoing research provides valuable information for understanding the effects of conservation practices on soil moisture, vegetation, and aquifer recharge in arid rangeland ecosystems.

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Accessible Adaptive Management: An Introduction to the Land Treatment Exploration Tool

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Abstract

Each year, public land managers make decisions regarding reclamation, rehabilitation, and restoration actions that influence landscapes and ecosystems. Many of these decisions involve soil and vegetation manipulations, often known as land treatments. These treatments were historically planned on a case by case basis with decisions about implementation, methods, and operations derived from personal experience of past successes or failures. Modern adaptive management strategies strive to capture this local knowledge through time, to create a comprehensive picture of effective treatment strategies both locally and regionally. In 2017, the U.S. Geological Survey partnered with the Bureau of Land Management (BLM) to create the Land Treatment Exploration Tool to facilitate adaptive management of land treatments. The Exploration Tool taps into a wealth of information about past treatments in the Land Treatment Digital Library (LTDL), a catalog of information about all known treatments on public lands administered by the BLM in the Western United States. The Exploration Tool is designed for resource managers to use when planning land treatments. The tool provides useful summaries of environmental characteristics of planned treatment areas and facilitates adaptive management practices by comparing those characteristics to other similar treatments within a specified distance or area of interest. This presentation will provide an overview of the functionality of the tool, highlight newly released features, and run through real world examples of how the tool is currently being utilized.

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Response of Degraded Rangelands to the Exclusion of Cattle Grazing within the Huascaran National Park, Ancash-Peru

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Abstract

The impact of grazing of livestock on vegetation in high-elevation Andean ecosystems are poorly studied despite the importance of these ecosystems to biodiversity and sustainability of local livelihoods. This study compared vegetation responses inside and outside of grazing exclosures in shrubland and grassland ecosystems over a two-year period. The study was conducted in Quebrada Ulta, on the western face of the Cordillera Blanca of Huascaran National Park (UNESCO World Heritage Site), Peru. Paired 15 × 15m cattle grazing treatments (exclosure = no grazing and control = grazing) were established in June 2014. Four replicate pairs (exclosure and control) were installed in each the shrubland (3800 m.a.s.l.) and the grassland ecosystems (4300 m.a.s.l.). Response in percent ground cover, aboveground biomass, floristic composition, and general rangeland condition were quantified at the beginning of the study and again after two years in the same season. Initial conditions did not differ significantly between the paired treatments and standard measurements of rangeland condition showed both ecosystems to be in “poor” (i.e. degraded) condition. After two years, percent cover of green vegetation, leaf litter, and aboveground biomass were significantly greater in exclosure compared to controls in both ecosystems while percent bare ground was lower. There was no change in Shannon-Weiner diversity in either ecosystem although there was a trend for increased percent cover of palatable species in the shrubland exclosures. After two years, the exclosure treatments in shrubland improved from “poor” to “fair” condition while the grazed treatment remained in “poor” condition. Condition of grassland treatments remined unchanged. Our study suggests that some ecosystem recovery can occur within two years of cessation of grazing in degraded shrublands but may take significantly longer in grasslands.

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Prescribed Fire and Invasive Woody Sprouters: Are We Trapped in a Fire Trap?

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Abstract

Prescribed fire is increasingly promoted as one of the most effective and sustainable land management applications available to resource managers to confront the global increase in woody plant encroachment on grasslands and rangelands. In certain instances where the woody species can be killed by fire, such as with Eastern redcedar (Juniperus virginiana), there is reason for optimism. However, a more significant problem occurs with woody species such as honey mesquite (Prosopis glandulosa) that can resprout after being topkilled. Our data show that, without loading extra fuel beneath the canopies of mesquite, drip torch initiated headfires in winter or summer with moderate grass fuel loads (2-3,000 kg/ha) are intense enough to completely topkill > 95% of mature mesquite, but cannot root-kill more that 2 or 3 % of the population. Regrowth following topkill is robust due to stored reserves in a massive root system and may grow faster with climate change. Thus, shifting mature stands of woody sprouters like mesquite into coppice thickets may require repeated fires at least every 5 years to maintain suppression indefinitely into the future. Similarly, we found that burning < 2-year-old mesquite seedlings increased root-kill to ~20-30% but surviving plants developed into a multi-stemmed thicket. The phrase "fire trap" coined in South Africa refers to keeping resprouting woody plants in a state of low growth suppression with repeated fires. This can be achieved if woody encroachment has not degraded the grass community. However, shifting dense, mature stands of woody sprouters into a resprouting physiognomy without significant root-kill might place resource managers into a scheduling "trap" where they will not be able to re-apply fire at a sufficient frequency to maintain suppression and enable grass restoration.

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Targeted browsing with goats for eastern redcedar (*Juniperus virginiana*) control

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Abstract

Eastern redcedar (ERC) (*Juniperus virginiana* L.) encroachment into grassland ecosystems, facilitated by shelter-belt tree planting and fire suppression, threatens the long-term health of Great Plains grasslands. Goats browse (defoliate and debark) juniper tree trunks and branches. Since ERC trees do not resprout, trunk girdling may kill the tree, making targeted browsing with goats a potential ERC control tool; however, very little field experimentation exists. The objective was to investigate how goats browse different ERC tree heights and its impact on tree mortality. A randomized complete block design was used with five sites comprised of four replicate paddocks browsed two consecutive summers. Up to ten ERC trees in five height classes (< 50, 51-100, 101-150, 151-200, and 201-250 cm) were permanently tagged in each paddock and browsing measurements and forage disappearance were recorded. Juniper height was negatively related with defoliation ($y = -0.28x + 72.1$; $R^2 = 0.39$; where x = plant height in cm) and positively related with debarking ($y = 0.12x$; $R^2 = 0.29$; where x = plant height in cm). Defoliation by volume reduction (%) was highest on trees < 100 cm tall and a greater percentage of the trunk was debarked on trees > 100 cm tall. On sites with less deciduous browse ERC trees 151-250 cm tall had more ($P = 0.003$) browned foliage and higher ($P = 0.01$) mortality than shorter, 51-100 cm juniper. Sites with higher deciduous browse had less debarking and less mortality. Eastern redcedar tree debarking and tree mortality success using targeted browsing with goats will most likely depend on the plant community composition. If sites contain more deciduous browse we would expect less debarking and mortality of ERC tress than sites containing only herbaceous forage and ERC trees as the woody component.

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Native Grassland Rehabilitation and Bee Demographics on the Texas Southern and High Plains

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Abstract

There are approximately 20,000 bee species in the world, and one-fifth of them are found in North America. Their sizes, appearances, and mannerisms differ from one another, but their importance in our ecosystem is universal. Bees are responsible for pollinating 80% of the flowering plants on Earth, but many of the species are endangered. One of the primary reasons is the loss of habitat. Our objective was to assess the number of native bees visiting three sites in the Texas Southern and High Plains undergoing conversion from cropland to native rangeland. The Bamert, Gipson, and Pantex sites were located near the towns of Muleshoe, Cotton Center, and Panhandle, Texas, respectively. At each site, we used pan traps (bee bowls) to catch bees in a four-hour time block (10:00 – 14:00 hrs.) during two time periods in Summer 2022: 1) early summer (May/June) and 2) late summer (July). Vegetation inventories were performed during these visits as well to better understand the relationship between vegetative composition and the number and species of bees collected. At this time, the majority of the vegetation present consists of volunteer species already present in the seed bank rather than the pollinator species mixes that we planted. Most of the bees collected at all three sites belong to the Halictidae family. At the Bamert and Gipson sites, *Lasioglossum* was the most common genus followed by *Halictus* and *Sphecodes*. No *Lasioglossum* were caught in either time period at the Pantex site, with *Sphecodes* being the most common genus caught at the site. Monitoring native bee populations in conjunction with site rehabilitation can provide another indicator of restoration progress besides revegetation. Documenting species richness and numbers captured within individual species can aid in understanding the mannerisms of these insects and predicting future observations.

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The Effects of Ventenata Removal on Rangelands of Northeast Wyoming

Marshall Hart, Brian Mealor

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Abstract

Ventenata dubia (Leers) Coss. is one of several annual grass invaders of the western United States. Ventenata dubia reduces forage availability for livestock and wildlife as well as lowers biodiversity in the Great Basin. This species has been spreading rapidly into the Great Plains, with populations in Wyoming, Montana, and South Dakota. Ventenata dubia has similar impacts, if not greater, to forage in this region than in the Great Basin. We ask if V. dubia control with indaziflam results in recovery of forage resources and biodiversity. At five sites in Sheridan County, WY, we sampled plots where V. dubia had invaded and was subsequently controlled, along with paired adjacent plots where V. dubia was left unmanaged. We collected and weighed biomass each month during the growing season for one and three years post-treatment. We also measured nutrient content each month in 2019 and took cover by species in July each year. Perennial grasses have higher crude protein and total digestible nutrients than V. dubia, and V. dubia control resulted in a positive perennial grass response. This effect lasted for the duration of this study. Additional benefits of returning to a perennial grass-dominated plant community come in the form of phonological differences. The differences growth patterns between perennial and annual species, with annual grasses quickly senescing early in the year, make perennial grasses a more dependable and longer lasting forage base. Species richness and diversity were unaffected by V. dubia control. Our results suggest that these sites have a high recovery potential. Managing V. dubia in the Northern Great Plains is possible and can improve forage resources for livestock and wildlife while maintaining species diversity.

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BLM Virtual Fencing Pilot Project and Landscape Level Application to Vegetation Treatments and Range Improvements

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Abstract

In 2021, the BLM implemented a 6 Base-Station virtual fence network that spanned 360,000 acres. Year One, 130 head were collared and the grazing permittee and BLM partnered to graze vegetation treatments and rest portions of BLM allotments. Year two (2022), 2000 cattle were collared in a 10 Base-Station Network that spanned approximately half-a-million acres of USFS, BLM, and Private land. In addition to the virtual fence technology this presentation will demonstrate the ability of multiple BLM resources (Range, Fuels, Wildlife, Hydrology, NEPA) partnering with grazing permittees and other agencies (NRCS, USFS, Colorado Parks and Wildlife) to design and implement Pinyon-Juniper/Sagebrush restoration Treatments (RX), construct and/or maintain water developments, aerial seedings, weed Rx, soil restoration/stabilization applied across a landscape level approach.

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Does annual grass invasion affect rangeland drought resistance?

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Abstract

The known distribution of Ventenata dubia (Leers) Coss in the Great Plains has been expanding. Counties in Wyoming, Montana, and South Dakota now have populations of V. dubia. Simultaneously, drought has affected much of this region. Following landscape-scale control using 123 g ae ha-1 of aminopyralid plus 123 g ai ha-1 of imazapic in 2017, and 73 g ai ha-1 of indaziflam in 2018, we collected biomass samples in paired treated and non-treated plots in two wet and two dry years. We answer how annual grasses, perennial grasses, and drought interact in this region using a linear mixed-model approach. We used perennial grass, annual grass, relative annual grass, and total plant biomass as dependent variables. We used annual grass biomass, perennial grass biomass, precipitation (high or low), and their interactions as fixed effects, with a random effect of plot nested within site. Annual grasses interacted with precipitation, leading to an inverse relationship between annual grass biomass and perennial grass biomass during drought, and a positive relationship in wet years ($p<0.05$). Perennial grasses did not exert the same influence on annual grasses ($p=0.74$), and there was no interaction between perennial grasses and precipitation affecting annual grasses ($p=0.99$). Annual grasses responded similarly to drought as perennial grasses as evidenced by: the relative proportion of annual grasses remaining constant regardless of precipitation ($p=0.10$), plots having similar total biomass in drought years regardless of functional group dominance ($p=0.20$), and the variation ($p=0.81$) and percent change ($p>0.89$) of total biomass from year to year being similar regardless functional group dominance. These patterns suggest that V. dubia and other annual grasses may become a larger issue in this region due to drought.

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The Economics of Ventenata Control in Northeast Wyoming

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Abstract

Invasive species pose a threat to the livelihoods of many people living on rangelands of the western U.S. Economic analyses often find that conservation practices, such as invasive species control, are not economically viable on private ranches, in contrast to what is found at the landscape scale. In the Great Plains, Ventenata dubia (Leers) Coss is rapidly invading, with populations found in Wyoming, Montana, and South Dakota. This annual grass reduces forage production on rangelands, putting strain on the livestock industry of this region. Our objective was to explore the economic costs of V. dubia over a three-year period for two options available to a ranch operation: purchasing extra hay to offset losses in forage, and controlling V. dubia with indaziflam, an herbicide increasingly used for annual grass control on rangelands. Using a partial budget analysis, we compare these two options in three invasion impact scenarios using a range of forage utilization rates (a factor somewhat analogous to productivity affecting rangeland area calculations) and discount rates. Controlling V. dubia with herbicide was a beneficial option over purchasing additional hay in many cases. In fact, in our highest impact scenario or at 50% utilization, it was cheaper to control V. dubia regardless of the discount rate tested. For lower grazing utilization rates with lower impacts of V. dubia, it was cheaper to purchase supplemental hay. There are many ranch-specific differences that may make different options more feasible, and we did not explore options such as reducing herd sizes. Our results indicate that controlling V. dubia can be an economically viable option under certain circumstances. For situations where purchasing additional hay is more cost effective, it is important to point out that we did not take into account the spread potential of V. dubia or the cost to neighbors of inaction.

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Prescribed fire and targeted herbicides may not be enough to restore invaded northern mixed-grass prairie

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Abstract

The Annual Brome Adaptive Management (ABAM) decision support tool (DST) was built to support vegetation management decision making, particularly regarding invasive annual brome grasses, of seven National Park Service units ("parks") in the Northern Great Plains. The ABAM DST is a state-transition Bayesian network based on scientific literature and 20 years of vegetation monitoring in those parks. In each year of an adaptive management cycle, the DST is updated with recent monitoring data, then used to quantify the state of the vegetation in each park management unit, compare the predicted outcomes of 10 different management actions for each of those units, and determine the optimal management action for the next year according to park managers' relative acceptance of different vegetation states. Management actions include no action, fall or spring fire, application of germination-inhibiting herbicides, and combinations of fire and those herbicides. Implementation of the ABAM framework and use of the DST in that framework began in 2021. Although the DST's predictive accuracy is expected to improve over time as more data accumulate, particularly for management actions involving herbicides, the current DST suggests that the management actions included in the ABAM framework may be insufficient to achieve managers' desired state of high-diversity mixed-grass prairie with low abundance of exotic species. While many management actions are better than no management at reducing exotic annual or perennial grasses in vegetation states where these species are abundant, none of the actions in the DST increases native plant diversity in these invaded states. Moreover, the "low quality prairie" state, which is characterized by low native diversity and moderate invasion of any kind and is common in these parks, is remarkably unresponsive to any management action. Actions that specifically promote native diversity, such as interseeding or possibly grazing, may be necessary to restore these grasslands.

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Increasing Feral Horses Adversely Affect Greater Sage-Grouse Nest Survival in Central Wyoming

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Abstract

Across portions of their range greater sage-grouse (Centrocercus urophasianus) have coexisted with free-roaming equids (feral horses [Equus ferus caballus] and burros [E. asinus]) since they were introduced to the rangelands of western North America by European settlers. Since the passage of the Wild Free-Roaming Horses and Burros Act of 1971, federal agencies have been responsible for managing free-roaming equids in the United States. Over the last 20 years, management has been hampered by shifting political views, budget limitations, and a decline in the public's willingness to adopt feral horses removed from the range. As a result, free-roaming equid numbers have increased to more than 3 times the targeted goal of 27,000. This goal is the cumulative sum of the Appropriate Management Levels (AML) for all designated Herd Management Areas (HMA) managed by the Bureau of Land Management. Recent research in Nevada has implicated these increases as one of the drivers of sage-grouse population declines, most likely due to habitat impacts that have been exacerbated by ongoing drought conditions. For sage-grouse, these habitat impacts most likely affect demographic parameters associated with reproduction. To test this hypothesis, we collected survival data for 752 nests laid by 465 unique female sage-grouse. These data ranged spatially across 6 HMAs as well as areas without feral horses, and temporally over 9 nesting seasons (2011–2019) in central and south-central Wyoming. Over this period, population estimates of feral horses for these HMAs ranged from 59–700% AML. We used these data to train a Bayesian hierarchical nest survival model to investigate the impact of feral horses. Nest survival decreased (β_{horse} = –0.084, SD = 0.048, F = 0.96) as feral horse numbers increased. These results indicate increasing feral horse numbers affected nest survival, one of the main vital rates influencing population growth of sage-grouse populations.

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Monitoring forest/grassland vegetation dynamics in northern Mexico using annual Landsat sensor data

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Abstract

The state of Chihuahua in northern Mexico has three large ecoregions: Sierra, Central Valleys and Desert. In the Sierra region, at a longitude of -107.4 and an average altitude of 2243 masl, the vegetation is composed of a not highly dense oak forest, together with understory grasslands. The low-dense oak forest vegetation is also connected to areas of open grasslands. Identifying the condition of the vegetation and the changes over time can help to detect areas or surfaces under pressure. The feasibility of using of remote sensing data to monitor the historical behavior of the oak forest and grassland area in the Teseachi Experimental Ranch was explored. Teseachi is located in the state of Chihuahua, in the municipalities of Namiquipa, Guerrero and Bachiniva, during the period 1990-2020. In the study area, annual grasslands are an essential component of the oak ecosystem, as they are the main source of forage for livestock and wildlife. We used 30-meter resolution Landsat 5 Thematic Mapper and Landsat 8 Operational Land Imager satellite data using the Normalized Difference Vegetation Index (NDVI). Spatial and temporal trends of vegetation in 10 paddocks in the study area were analyzed based on spectral data, comparing year to year using linear regression and ANOVA. In general, the results indicated that the condition of the vegetation decreased over the last 20 years. In addition, it was possible to detect the impact of vegetation changes on the temporal scale. The impact of management in the different paddocks of Teseachi varied in their NDVI behavior both spatially and temporally. According to the results, employing the NDVI as a spectral indicator seems to be a useful to analyze vegetation dynamics.

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State and Federal Collaborative Efforts to Improve Elk Winter Range on the Smith River Wildlife Management Area (Montana) through Targeted Cattle Grazing

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Abstract

Bisected by the Smith River, the Smith River Wildlife Management Area (WMA) historically operated as a cattle ranch. It has been ungrazed by livestock since Montana Fish, Wildlife and Parks (MFWP) purchased it in 1960 for elk winter range. Currently, the WMA provides key winter habitat for elk during years of above average snowfall. Even with as many as 500 wintering elk, the agency has grown increasingly concerned about decadent and unhealthy grasslands on the WMA. To determine the extent of the situation, ecological status was determined for 19 randomly identified sites in August 2022. High use and highly decadent areas contrasted strongly indicating uneven grazing across the WMA. Fieldwork revealed that grassland decadence may be due, in part, to conifer encroachment. The combined ecological data will form the basis for a new management plan. The initial effort to re-invigorate elk winter range centers on a collaborative effort between MWFP and the Helena-Lewis and Clark National Forest, to develop a grass bank grazing system for cattle displaced by prescribed fuel treatments, extended rest periods, or other conservation projects on US Forest Service (USFS) allotments. Targeted grazing management will be used on the WMA to reach the overarching project goals of improving elk winter forage conditions and protecting the Smith River corridor. This coordinated effort will also require creative water developments and redesigned interior fencing. The successful plan will provide 1) a healthy, resilient grassland complex, b) improved elk winter forage, c) management flexibility for USFS allotments, d) ease of recreational access to the Smith River, and e) unhampered wildlife movement within the WMA. The fully developed grass bank management plan will be presented at the annual SRM meeting.

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Increased Vulnerability of the Nebraska Greater Prairie-Chicken Stronghold to the Advancing Woody Biome

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Abstract

Greater prairie-chickens (*Tympanuchus cupido*, hereafter GRPC) are an iconic grassland species in the Great Plains. Healthy populations of GRPCs indicate intact, heterogeneous grasslands. Grasslands are the most imperiled ecosystem in the world, currently under great threat from woody encroachment. This threat has created a biome-scale woodland transition in the Great Plains. The front lines of this alternative woody biome boundary are currently in the state of Nebraska. It is well documented that GRPCs are highly sensitive to woody cover. As exposure to the alternative woody-state increase, GRPC population vulnerability also increases. Here, we will show the GRPC population stronghold's proximity to the alternative woody biome boundary. This will serve as an indicator of potential heightened population vulnerability to future vegetation change and habitat loss.

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Quantifying and describing woody plant encroachment risk in the Great Plains

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Abstract

Grasslands are an imperiled biome and woody plant encroachment is among the most aggressive threats to these systems. In the grasslands of North America, widespread fire suppression has resulted in large-scale woody plant encroachment, ultimately causing regime shifts from open-biome grasslands to closed-canopy woodlands. This phenomenon has direct and concerning consequences for range productivity and biodiversity. Theory predicts that the most effective approach to slow the advance of juniper woodlands is to focus management efforts on protecting areas that have not yet undergone a regime shift (rather than try to win back areas that have already transitioned). Therefore, it is critically important to understand the location and extent of areas most vulnerable to woody plant encroachment for a proactive management strategy. Here, we use multiple, continental-scale, annual-resolution datasets to assess the advancement of woody plant encroachment in the US Great Plains over the past three decades. Specifically, we map and quantify the extent of areas most at risk of woody plant encroachment and elucidate whether the extent of vulnerability has increased across the temporal extent of the study. We also quantitatively assess the landscape configuration of the largest, contiguous tracts of intact grassland remaining. Our findings illustrate an increasing trend in vulnerability and have actionable implications for range productivity, grassland conservation, and biodiversity.

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Adapting Rangeland Monitoring Protocols to Central American Agricultural Lands

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Abstract

RainDrop and Synergy Resource Solutions, Inc. (Synergy) worked with Catholic Relief Services and the Howard G Buffett Foundation to adapt protocols from the Monitoring Manual for Grassland, Shrubland, and Savanna Ecosystems (Herrick et al. 2017) to agricultural lands in eastern El Salvador. Although this region has a tropical climate and was historically forested, the vast majority (90+%) has been deforested. Initial objectives for the project were to provide ground truth data for remote imagery. The protocols proved to be effective in providing data useful not only to landscape scale projects led by international Non-Governmental Organizations, but to be applicable to at the farmer scale. By developing multiple experimental designs with expert backstopping, RainDrop has demonstrated increasing year-round vegetative cover by 30-50%, soil erosion reductions by nearly 100 tons per hectare, and improved infiltration of over 1,000 cubic meters of rainfall per hectare. Changing land uses and climate have created conditions that made rangeland data collection protocols applicable to former tropical forests.

RainDrop formed in 2019 by young entrepreneurs after attending conservation agriculture and restoration science training. The group proposed a long-term training program that culminated in them forming a business dedicated to restoration science along with monitoring land use and soil health impacts on farms. By developing multiple experimental designs with expert backstopping, RainDrop has demonstrated increasing year-round vegetative cover by 30-50%, soil erosion reductions by nearly 100 tons per hectare, and improved infiltration of over 1,000 cubic meters of rainfall per hectare.

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Niche divergence of a drought-deciduous shrub and its implications on range expansion under changing climate scenarios

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Abstract

The dynamic nature of a species' geographical distribution reflects the evolution of its niche as individuals interact with environmental heterogeneity. Through this process a pattern of either niche conservation or niche divergence will appear. Recognizing which pattern is occurring will be key to predicting species' responses as climate change increases vegetation exposure to novel conditions within their distribution. Whitebrush (Aloysia gratissima) is a drought-deciduous shrub species with two geographically distinct populations occurring in North and South America. This species is often the target of management practices as it can develop monocultural stands, resulting in decreased biodiversity and forage availability in rangelands. Our goal was to explore the environmental variables that constrain distribution spread, how this varies between populations, and what impact that will have on future distributions. We conducted a Principal Components Analysis to compare climatic conditions present throughout each population and used the ExDet software to identify geographical areas representative of climate novelty. We then modeled the ecological niche at the species and population level using MaxEnt using abiotic (climatic) variables. We spatially transferred the characterized niche of each population onto the alternate's geographical extent. Variable contribution of the population level models and performance metrics of the spatial transference models were used to evaluate differences in vegetation-climate relationships. Finally, distribution shifts were modeled under future climate scenarios to contrast predicted expansion and reduction of population distributions. Comparison of abiotic conditions between populations showed evidence of non-analogous climates and spatial transferability was poor (TPR 3.06%, 3.57%) suggesting niche divergence is occurring between populations. Differences in top performing variables across population models suggested the northern population is limited by temperature extremes while moisture availability constrains the southern population. Predicting species behavior and identifying driving interactions will allow for adaptive management strategies in current and future climate scenarios.

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Influence of fall and winter grazing on subsequent year Sandhills subirrigated meadow plant production

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Abstract

Subirrigated meadows in the Nebraska Sandhills provide multiple ecosystem services, including a valuable forage resource to cattle ranching operations. Meadows are primarily used for hay production, but grazing during the growing season or a combination of haying and grazing on plant regrowth later in the year are also options commonly employed. Our study evaluates the effect of grazing meadow hay regrowth during the fall (pre-plant dormancy) and winter (post-plant dormancy) months at moderate and heavy grazing intensities to better understand the potential interaction between grazing intensity and time of grazing on subsequent year plant biomass production. Over 3 yrs, grazing in the fall, when vegetation was still growing, reduced ($p = 0.02$) graminoid production during the subsequent summer by approximately 10% compared to grazing occurring during the winter, when grasses were dormant. Relative to fall grazing, postponing grazing until plant dormancy in the winter returned higher yields of graminoids that were similar ($p = 0.90$) to a no-graze control. Subsequent year standing dead and litter material was more influenced by intensity of grazing than the time when grazing occurred with 60% less ($p < 0.01$) standing dead and litter in the heavy grazing compared to the no grazing control. Quality of subsequent year's forage with fall grazing was higher than the control or winter grazing, which may be the result of variable forb amounts by year in the fall grazed plots. Fall and winter grazing on subirrigated meadows provides a valuable forage resource and timing of grazing has an influence on the subsequent year production, but trade-offs, such as higher quality forage in the fall compared to winter, might offset reduced biomass during the subsequent growing season.

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Restoring Heterogeneity: The Impact of Creating Soil Mounds and Slash Piles on Species Diversity at a Disturbed Sagebrush Parkland.

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Abstract

Efforts by resource managers to increase native plant diversity in California Park, a high elevation sagebrush parkland in northern Colorado designated as a Forest Service Special Interest Area, have largely been ineffective. Our study investigates if restoration treatments that create resource heterogeneity and generate niches for plant establishment, can increase native plant diversity and improve restoration success. In 2018, replicated test plots containing four treatments (unseeded control, seeded only, seeded plus soil pits and mounds, and seeded plus slash) were established at degraded sites in California Park. In the summers of 2019-2022, seeded species density and unseeded and seeded plant species cover were sampled. We analyzed treatment effects on seeded species Shannon-Wiener diversity (H), species richness, and plant abundance with linear mixed-effects modeling. Our findings demonstrate that, while all treatments increased species diversity and richness compared to control plots in 2019, by 2022 this trend diminished. In 2022, mounds and seeded plots still contained higher seeded species diversity than control plots ($p < .05$) but there were no differences in terms of species richness. Particular species, such as Yarrow (Achillea millefolium) and Purple oniongrass (Melica spectabilis) were more dominant than other seeded species, and differences in their abundances between treatments may have driven the diversity results. Overall declines in richness, diversity and abundance from 2019 to 2022 may be attributed to hotter and drier conditions, as well as high levels of insect herbivory in 2020 and 2021. These findings provide insight into whether increasing soil resource heterogeneity and adding a high-rate, diverse seed mix may set these degraded sites on desirable plant community trajectories.

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Does cattle selection matter? Testing larkspur-native vs larkspur-naïve cattle to reduce death losses on larkspur infested rangelands

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Abstract

Tall larkspurs (Delphinium spp.) are native plants that grow on mountain rangelands of western North America and have a long history of poisoning grazing cattle. Ranchers that graze cattle in rangelands with large populations of toxic larkspur often have yearly herd mortalities up to 10%. These losses amount to millions of dollars due to animal deaths, increased management, and veterinary treatment costs. The proper selection of replacement animals for grazing on larkspur containing rangelands is important. For example, ranchers often describe that the greatest larkspur losses occur with replacement animals, and once the initial losses are over, larkspur poisoning is much less of a problem. In this study, we compared animals from a herd grazed on larkspur-containing pastures (larkspur-native) to cattle from a herd that have never been exposed to larkspur (larkspur-naïve). We hypothesized that larkspur-native animals would consume less larkspur than larkspur-naïve cattle. The experiment was conducted in eastern Idaho on a mountain rangeland containing tall larkspur. Six native and six naïve Angus steers grazed in July 2022 when larkspur was in the flowering stage. Two animals from the same treatment group were randomly assigned to one of six pastures. Daily bite counts were used to determine animal diet composition. There was a tendency for naïve cattle to consume more larkspur (3 ± 0.4 % of diet; $P = 0.056$) than native cattle (1 ± 0.2 %) over the course of the grazing study. However, more of the native cattle showed signs of intoxication. The study will be repeated a second year to determine if naïve cattle consistently consume more larkspur than native cattle, and to determine if there is a difference in native or naive cattle becoming intoxicated.

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Non-target effects of prairie dog conservation and control on harvester ants (*Pogomyrmex* sp.)

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Abstract

Harvester ants (*Pogonomyrmex* sp.) are an important granivore and seed-disperser in many rangelands and are also a critical food source for imperiled horned lizards (*Phrynosoma* sp). Because harvester ants prefer bare ground, they often inhabit black-tailed prairie dog colonies (*Cynomys ludovicianus*). Despite ecosystem services of both prairie dogs and harvester ants, they are commonly considered agricultural pests and lethally controlled. Control efforts have reduced populations of both species, but non-target effects of management for one species on the other have been understudied. Specifically, management to control prairie dogs often relies on a grain bait coated with zinc phosphide (a toxicant), which harvester ants may also move and consume. Interestingly, even targeted actions meant to protect prairie dogs could have negative impacts on harvester ants; fipronil (an insecticide) grain is recently being used to reduce prairie dog flea loads in hopes of reducing the spread of plague among colonies. While this method will be relatively low-impact on most other invertebrates, granivorous harvester ants may be especially at risk. We designed an experiment to evaluate effects of prairie dog control (zinc phosphide) and conservation (fipronil) on harvester ants. We examined individual ant responses to both grain types versus a control, and also deployed small amounts of both bait types and untreated grain near colonies and observed responses. Preliminary data collected in Oklahoma on *P. barbatus* indicate high uptake of all grain types. We observed mortality of individual ants exposed to zinc phosphide but did not observe colony collapse within 7 days of treatment. We observed both individual mortality and a single colony collapse after 4 days after treatment with 0.0054% fipronil-treated grain. While we highlight that this work is preliminary, we believe it indicates a need for holistic thinking regarding prairie dog management in the Great Plains.

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Landscape use and activity patterns of feral swine (*Sus scrofa*) on rangelands in the Rolling Plains of North Texas

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Abstract

Feral swine (*Sus scrofa*) inhabit 35 states in the US with an estimated population of 6 million animals. The feral swine population is greatest in Texas with an estimated population of at least 2.5 million. Monitoring swine landscape use and activity patterns is the first step to understanding potential zoonotic disease spillover events with livestock. Swine populations are highest in densities in forested regions, but as their range expands, they will continue to encounter novel ecosystems. The Rolling Plains ecoregion of Texas presents a unique landscape in which feral swine are found in midgrass prairies primarily used for livestock production. Two 405 ha survey areas were chosen from a ranch in north Texas to stratify game cameras across three vegetation types: bottomland, deep upland, and shallow upland. From June 2021 to May 2022, cameras monitored animal movement. Swine captures were logged and tagged with date, time, and temperature. Vegetative surveys were also conducted to get estimates of herbaceous biomass production and vegetation height around the camera locations. Total swine captures ($n = 242$) over the study period were analyzed through mixed model analysis with terms of season, time, and vegetation type with interaction models run. Swine captures were significantly higher at bottomland sites than deep upland sites across fall, winter, and spring seasons ($P \leq 0.012$), as well as mid-morning time blocks (8:00-11:59) ($P \leq 0.029$). Temperature was also a significant driver of swine activity ($P < 0.001$) with low activity occurring at the extremes (≤ 0.0 °C and ≥ 30.0 °C). Herbaceous biomass production and vegetation structure were not good predictors of swine activity. These results can better inform producers where and when swine may be present within their ranches, increasing efficiency of feral swine management.

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Physiological advantages seen in a C3 grass invading C4 grasslands

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Abstract

Mexican feathergrass (*Nassella tenuissima* (Trin.) Barkworth) is a C3 bunchgrass native to the Trans Pecos region of West Texas. It has been planted as an ornamental in many other regions of Texas. Feathergrass can escape from landscaping areas and become a weedy species on disturbed rangelands, including the 160-acre (54-ha) native shortgrass prairie at Texas Tech University. To understand any physiological advantages this species may have within this environment, we surveyed three *N. tenuissima* colonies throughout the TTU rangeland. We selected *N. tenuissima* from three locations within the colonies: inner, edge, and outer for physiological measurements. We also monitored two 'companion' native grasses adjacent to the feathergrass in the outer location: blue grama (*Bouteloua gracilis* (Kunth) Lag. *ex* Griffiths) and purple threeawn (*Aristida purpurea* Nutt.). We measured leaf-level gas exchange (i.e., photosynthesis, transpiration, and stomatal conductance) in May, June, and July 2022. Leaf water potential was also assessed across these months during predawn and midday measurements. Threeawn exhibited greater transpiration rates than feathergrass (P = 0.0008). In May, feathergrass photosynthesis rates were greater than those of threeawn (P = 0.002). Predawn leaf water potential was lower in blue grama than feathergrass (P = 0.048), indicating lower water stress during the summer drought. Feathergrass appears to exhibit greater water use efficiency and less water stress than the surveyed native grasses, which likely contributes to its expansion in the local region.

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Improving Degraded Sagebrush Rangelands Using Fall-Winter Grazing on Public Lands in Southeastern Oregon—A Fuels Reduction Research & Education Partnership

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Abstract

Sagebrush rangelands are one of the most imperiled ecosystems in America due in large part to threats from invasive annual grasses and recurring wildfires. In the last decade alone, 2.5 million acres of sagebrush rangelands have burned in wildfires with perimeters either entirely within or that encroached into Malheur County—located in northern Great Basin of southeastern Oregon. To address these ecological challenges, a strategic research-partnership was formed between the Vale District Bureau of Land Management (BLM) and Oregon State University with input and support from broad public partners. The partnership was formed in 2016 and formalized as a Fuels Reduction Grazing and Education Project on three pastures (8700 ha) within the Three Fingers Allotment. We hypothesized late-fall and winter (dormant) season grazing could be applied at the landscape scale, outside the traditional seasons of use, to improve ecological outcomes. Short-term research goals were to implement dormant season grazing to reduce fine fuel amounts, whereas the long-term research goal was to implement fall-winter grazing to facilitate succession toward plant communities resilient to disturbance and resistant to invasive annual grasses. We will share critical process steps that enabled the project, including a timeline with actions that facilitated a BLM Decision of Record authorizing the project. Furthermore, we will share innovative approaches we employed to disseminate information to a broader and diverse audience during the COVID-19 pandemic. We will also share practical experiences from our partnership and provide the audience with key successes and challenges associated with dormant season grazing in a large, heterogenous landscape, with unpredictable weather, and development of supporting infrastructure on public lands, while balancing project objectives with profitable grazing operations. Finally, lessons learned from our field findings will highlight that strategic partnerships can generate “small wins” that are critical for enabling collective action and broader ecological impact.

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Assessing Adaptive Invasive Annual Grass Management via Landscape-scale Vegetation Monitoring

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Abstract

Ventenata (Ventenata dubia (Leers) Coss.) and medusahead (Taeniatherum caput-medusae (L) Nevski.) were identified in Sheridan County, Wyoming in the summer of 2016. Shortly after, the Northeast Wyoming Invasive Grasses Working Group (NEWIGWG) was established as a multi-stakeholder group aimed at containing or eradicating both species. Using vegetation survey and monitoring to inform management is critical for NEWIGWG to answer questions related to species presence, treatment efficacy, and retreatment intervals. From 2017-2022, the group surveyed 42,600 acres prior to treatment, treated 113,228 acres, retreated 10,553 acres, and monitored 8,391 vegetation sampling points throughout Sheridan and Campbell Counties, Wyoming. Indaziflam treatments reduced ventenata and medusahead abundance, but did not have consistent control across the landscape. Monitoring efforts led to the identification of two new medusahead populations in 2021. Indaziflam treatments appear to be losing effectiveness at 3 years after treatment with short-term efficacy being highly dependent on precipitation. Future work will include determining retreatment intervals for the most efficient annual grass control and continued collaborative efforts toward managing invasive annual grasses.

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Forecasting sagebrush restoration potential from seed across the Great Basin using structured population models

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Abstract

Due to the rise in large and frequent wildfires, the distribution and abundance of big sagebrush (Artemisia tridentata) has been fundamentally altered. Sagebrush is a foundational species of the sagebrush-steppe ecosystem and as such, land managers have put forth significant investments in seeding recently burned areas to restore habitat. However, the extent to which these restoration efforts are successful is highly variable, particularly in low elevation locations. Despite a rapidly growing body of research identifying factors that limit the recovery of sagebrush after fire and subsequent restoration seeding, we still lack quantitative, data driven and probabilistic estimates of how likely sagebrush recovery is at newly burned sites after seeding, and how long it may take before stable populations are established. Such estimates could be valuable to land managers responsible for allocating limited resources for ecosystem rehabilitation, and for devising alternative strategies (e.g. planting individuals) when traditional approaches (e.g. seeding) are unlikely to succeed. Using data from 597 sites across the Great Basin that were burned, seeded, and subsequently resampled, we are developing data driven forecasts of sagebrush restoration potential after wildfire and seeding. Predictions from our structured population model will then be validated using independently collected out-of-sample data. Model output will provide useful estimates of the probability of time it will take big sagebrush populations to reach Greater Sage-grouse habitat guidelines.

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Rohrbach Cattle Ranch South Dakota Excellence in Range Management

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Abstract

The Rohrbach Cattle Ranch is located near Roscoe, South Dakota in Edmunds County in the north central part of the state. The ranch has been in the family since Jonathan's grandparents started it in 1923. The ranch consists of approximately 2,100 acres of native rangeland and 200 acres of native prairie hay. There is also 500 acres of cultivated ground, of which 140 acres is a tame grass-alfalfa mix. The Rohrbachs run 230 cow/calf pairs and 100 yearlings, of which they keep 40 as replacements each year. The major goals of the ranch include: restoring the land to what it used to be when Lewis and Clark traveled through the prairie, making a profit with low inputs, drought-proofing the land, and keeping residue on the ground to reduce evaporation and establish roots. The ranch utilized multiple conservation programs to make major improvements beginning in 2006 including cross fences, water tanks, and pipeline. Cattle are now rotated on a once or twice through each year basis, moving every 7-10 days. Jonathan understands the importance of leaving grass in pastures after grazing, even though it may be tempting to continue to let the cattle graze the remaining grass. He says, "You're not losing what's there. It's benefiting the biology and the plant to regrow and give you more when it comes back."

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Evaluating Bulbous Bluegrass Control by Various Herbicides

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Abstract

Bulbous Bluegrass (Poa bulbosa) is an invasive perennial grass that was intentially introduced to the US in 1906. Bulbous bluegrass was tested as a turf grass but performed poorly. Then it was momentarily used in restoration seed mixes to compete with cheatgrass in southern Idaho. Now bulbous bluegrass is considered an invasive short-lived perennial. It is adapted to areas with dry summers, mild winters, and winter-dominated precipitation and the only grass in North America that reproduces via bulblets. Although it is widespread throughout the west, research is limited on bulbous bluegrass control methods. We evaluated the efficacy of various herbicides in controlling bulbous bluegrass. We have results from two field sites, one treated with 11 herbicides + Roundup in April of 2018 and monitored every year for 4 years after treatment (YAT), and one treated with 10 herbicides in November of 2021 and monitored one YAT. We estimated control (%) of bulbous bluegrass and damage (%) to perennial species in both field sites. Indaziflam + imazapic showed greater initial control and better long-term control than either herbicide alone. Imazapic provided good control in the first year after treatment, but control diminished by 4 YAT. Perennial grasses at 1 YAT were only impacted by herbicide treatments that included aminocyclopyrachlor and rimsulfuron. Further research should evaluate efficacy under various application timings and non-target effects in treatment areas.

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Using UAVs to Quantify Forage Production of a Pastureland

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Abstract

Unmanned aerial vehicles (UAVs) have shown to be accurate when estimating forage production in pasturelands. Pasturelands are land dedicated to the production of forage for harvest by grazing, cutting, or both. Estimating forage production aids ranchers with management decisions involving stocking rates and grazing systems. Our objective was to estimate forage production in pasturelands using UAVs and compare them to the total forage produced through hay production. We flew two study sites, representing two pastures, (12.2 ha and 1.2 ha) in Freestone County, Texas. Prior to the UAV flight we selected and marked 30 quadrats throughout each field on a vegetation gradient of 1-5 with 1 being the lowest vegetation present and 5 being the highest. After each flight, the 30 quadrats were clipped, dried, and weighed. Each field was cut, cured, and baled within a day of UAV flight. We measured an average bale weight of 650 kg and 499 kg at the large and small pastures. We used this information to calculate total weight and divided by the area cut to obtain forage production. We processed UAV imagery to create a normalized digital surface model to calculate plant height. We classified plant height into the 5-vegetation gradients used in the field using the quadrat locations. The area for each class was calculated and multiplied by the dry weights collected from the quadrats to predict the total forage production for each class. The largest pasture produced 106 round bales with a forage production of 5,871 kg/ha. The smallest pasture produced 4.5 round bales with a forage production of 2,219 kg/ha. We were able to predict within less than one bale weight difference between UAV data and field data for both fields. UAVs could serve as a new tool for estimating forage production, aiding ranchers with management decisions.

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Predicting bulbous bluegrass green-up using weather and soil measurements and remote cameras in eastern Idaho

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Abstract

The sagebrush (Artemisia ssp.) steppe ecosystem is one of the most endangered ecosystems in the western U.S. due to multiple threats including non-native annual grass invasion and increased frequency and size of wildfires. Livestock grazing has been suggested as a tool to reduce fine fuels and promote sustainable native plant communities on rangelands, however, timing of livestock grazing is critical. Managers and producers need better information on factors that control plant green-up to determine a time when livestock grazing can be applied to target specific grass species such as bulbous bluegrass (Poa bulbosa) while limiting negative impacts on desirable perennial grasses. Our objective was to predict bulbous bluegrass green-up using soil moisture/temperature, weather, and remote RGB camera imagery. Our study sites are located near Pocatello and Malad City, ID within intact sagebrush steppe communities at 5000ft elevation. At each site, weather sensors and SoilVUE 10 (Campbell Scientific, Inc.) were installed. Wingscapes cameras (Moultrie) were placed at each station and programmed to take 10-megapixel photos with temperature and time imbedded every hour from 6am to 10pm for two months during potential green-up conditions. Assigned camera values were compared to ground measurements to assess plant green-up and identify potential metrics (e.g., soil moisture and temperature) that may be beneficial to landowners and management agencies when implementing targeted grazing on bulbous bluegrass in intact sagebrush steppe plant communities.

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Livestock Mortality Composting in California

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Abstract

When a large animal dies on a farm or ranch, there are often few options for disposal. In California, there are even more limited options especially as rendering facilities have closed, and both regulatory burden and the number of predators on the landscape have increased. Livestock mortality composting could be a viable solution to address these challenges. Composting of mammalian tissue is legal in most states and recommended for on-farm disposal of livestock mortalities but is currently illegal in California. Instead, many ranches have opted to use “bone piles” to dispose of livestock mortalities. This option has been shown to attract large predators such as wolves, mountain lions, bears etc. making it a hazard for livestock operations by increasing the likelihood of livestock-predator interactions. Removing these bone piles is the number one predator attractant removal recommended by Oregon Department of Fish and Wildlife. Mammalian tissue composting is also a viable option for waste from on-farm animal processing especially as this practice has become more popular in the last few years. After navigating the regulatory oversight of multiple local and state agencies, a livestock mortality composting site was approved for research at the Intermountain Research and Extension Center in Tulelake, CA. This site has composted four adult cows and demonstrated the effectiveness and safety of this process while working within California regulations. Trail cameras were used to assess predator visits to nearby bone piles and the research compost pile. Results will be shared from both the compost pile and trail camera studies. A best management practices document has been written to provide an on-farm livestock mortality composting exemption that falls within current California composting laws. This exemption could be carried out at the local, regional, or state level, although permanent changes to this policy will most likely need a legislative change.

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Variation in drought responses and restoration applications for pinyon pine

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Abstract

Fires and drought have caused widespread impacts to semiarid woodlands across the Great Basin, resulting in the loss of ecologically- and culturally-important stands of *Pinus monophylla* (singleleaf pinyon pine). Following overstory losses, restoration is challenged by an incomplete understanding of tree establishment requirements, complicated by intraspecific variability in establishment responses across the species' range. Information on trait variation and corresponding seedling responses to drought can inform restoration decisions, including the selection of seed sources. We quantified trait variation among adult trees and seedling offspring from 23 sites distributed throughout the range of *P. monophylla*. We then used common garden experiments to assess seedling responses to a range of drought scenarios. Despite high trait variation among individual trees within sites, seed and needle traits were consistently structured along regional gradients of aridity and precipitation seasonality, providing indirect evidence of local adaptation. Trait differences were maintained in seedling offspring grown in a greenhouse: under a broad range of water availability, seedlings from more arid climates produced larger aboveground and belowground biomass compared to seedlings from more mesic environments. These differences were associated with meaningful differences in performance in a field common garden experiment, where seedlings sourced from arid climates had higher survival under multiple simulated drought scenarios. Results suggest that the selection of drought-adapted seed sources can improve restoration success, particularly given climate-change-associated trends towards increasing frequency and severity of drought. Ongoing work includes outplanting trials in burned and unburned landscapes, aiming to improve management efforts for restoring woodland ecosystems for cultural and ecological values.

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Using rock detention structures to slow erosion in ephemeral streams: A 10-year case study

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Abstract

On southern Arizona rangelands, the channelization of ephemeral water flows can result in the deepening of water tables, decline in local soil moisture, loss of vegetation, and a negative feedback cycle of watershed degradation. Problems are exacerbated by climate change and its increasingly unpredictable precipitation regimes. Active watershed rehabilitation methods to reverse the negative effects of soil erosion typically include manipulating vegetation to influence interception of precipitation, water infiltration, and sediment transport. Installing low-tech rock structures in streams and channels can reduce channel incision and formation of headcuts. Here, we analyze the impact of induced meandering rock detention structures on vegetation using a case study experiment of ephemeral streams located in the Altar Valley of southern Arizona that were treated with one rock dams and baffles. Using ten years of vegetation monitoring data, we (1) compare temporal trends between channel treatments; and (2) employ structural equation modeling to reveal indirect effects between treatment, soil nutrients, and vegetation cover and diversity ten years after structure installation. Overall, rock structures increased herbaceous vegetation cover and perennial plant diversity through the enrichment of soil nitrogen. This project illustrates the importance of long-term monitoring, and integration of soil and plant data to understand more complex ecosystem relationships.

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Post-Fire Grazing of Perennial Rangeland Systems

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Abstract

Vegetation response to wildfire is variable and depends on multiple and interacting site factors, including pre-fire plant community, burn intensity, and post-fire weather. One of the first questions that arises after rangeland fire is whether the area should be rested from grazing the following season. While grazing rest is a viable option in some cases, it is not always necessary. Specific decisions about grazing management including whether or not to rest from grazing, should be based on field assessments made in the spring following fire. A framework for land managers and livestock producers relating to the timeline, key considerations, and management options following wildfires on perennial rangelands will be presented.

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Predicting Litter Biomass in Degraded Sagebrush Rangelands of the Northern Great Basin

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Abstract

Invasion of non-native (exotic) annual grasses, such as cheatgrass (Bromus tectorum Huds.) and medusahead (Taeniatherum caput-medusae [L.] Nevski), promotes a grass-fire cycle that perpetuates exotic annual grass invasion and dominance in rangelands of the northern Great Basin. Understanding the extent and distribution of litter biomass in these plant communities is of paramount importance when evaluating the risk of large and frequent wildfires. These data can help rangeland managers develop adaptive management strategies and make more informed decisions. There is a paucity of spatially-explicit methods to estimate litter so we evaluated the potential of remote sensing products to estimate litter accumulation in degraded sagebrush rangelands within the Three Fingers Allotment, managed by the Vale District Bureau of Land Management in Malheur County of southeastern Oregon. Every June, from 2018-2021, litter biomass was measured in 24 field plots. We used two remote sensing-derived products to predict litter biomass measured in the field plots: (i) annual net primary production (NPP) product partitioned into plant functional traits from the Rangeland Analysis Platform at 30m of spatial resolution; and (ii) topographic variables computed from USGS National Elevation Dataset at 30m—in particular heat load index (HLI) and site exposure index (SEI). Using a frequentist model averaging approach (FMA), we determined that the NPP of annual and perennial grasses, as well as HLI and SEI, were important predictors of litter biomass measured in the field plots in 2018 (R^2 = 0.61). Model extrapolation based on the transfer of the FMA predictive relationships from 2018 to the following years provided similar overall fits ($R^2 \approx 0.5$). Our findings suggest that the proposed remote sensing-derived products could be used to predict litter biomass, which may allow rangeland and fuels managers to prioritize areas and mitigate the negative effects of future annual grass-fire cycles.

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Finding common cause with community pastures patrons

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Abstract

In 1935, the federal government of Canada established a Community Pasture Program (CPP) run by the Prairie Farm Rehabilitation Administration (PFRA) to conserve lands degraded by tilling and heavy livestock grazing made worse by a prolonged drought. From its start until the 1970s, 630,000 ha of land were entered into the CPP. Similarly, the Saskatchewan Pasture Program (SPP) began in 1922 and included 313,000 ha when it ended in 2017 with the provincial government citing changes in the agriculture industry that made the program unnecessary. Collectively, these blocks of government-managed lands were known as community pastures and were in nearly every ecoregion of Saskatchewan. These lands supported cooperative grazing for regional livestock production with economic and biodiversity objectives jointly achieved by teams of professional range managers, biologists, and planners. When both programs ended, existing pasture patrons were left to manage these lands and their values without these supports.

Individual community pastures form key nodes in the Nature Conservancy of Canada's (NCC) landscape-scale conservation plans. Prior to the end of pasture programs, NCC had several partnerships with individual pastures aimed at forwarding joint biodiversity conservation objectives. Examples include endangered species surveys and ongoing fence-sharing discussions.

Since the community pasture programs ended, NCC has started a working landscapes program that supports mutually beneficial outcomes developed via relationships with pasture patrons and managers. Outcomes have ranged from best management practices for species at risk, to multi-value grazing management plans, to targeted infrastructure projects. As a non-governmental agency NCC's has the flexibility to support efficient, unique strategies that arise from identifying shared values. These experiences are relatively unique in the Canadian prairies and the lessons learned and shared will improve future projects as the NCC's work with community pastures continues to evolve.

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Working with ranchers to improve rangeland wildfire preparedness outreach

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Abstract

Ranchers in the U.S. West face unique challenges when it comes to planning for and recovering from wildfire. Not only is there potential for financial loss, some functional and social aspects of ranching can be affected in unexpected ways. Current resources, program offerings, or policies may overlook outreach strategies that may better enable ranchers to prepare for or recover from wildfire events. We present preliminary findings from an Extension-oriented study of Oregon and Nevada ranchers who have experienced large wildfires within the last decade. Using semi-structured interviews, we sought to understand the activities and decisions participants have undertaken to (1) prepare their ranch operations for wildfire, and (2) recover from incidents in which they lost property, livestock, or forage. Qualitative analysis of these data explored the activities, decisions, and impacts identified by participants by categorizing types of “costs” borne by participants (e.g., financial, social, operational). We find effects of wildfire on ranches are not felt the same way for every operation, with number of livestock, geographic extensiveness, public and private land composition, and reliance on year-round grazing (as opposed to hay) emerging as relatively important factors in the effects of wildfire on an operation and its recovery. Immediate economic losses identified included loss of fencing, livestock, grazing land, and stored hay. These losses led to longer term social and operational costs such as the need to reconfigure operations or change succession plans. Participants viewed fuel reduction on federal grazing allotments as a principal need for readying their operations for wildfire. Our findings point to a need for new rancher-focused models in Extension outreach and planning in this region and beyond.

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Protecting rangelands in a changing climate: Using a heritage cattle breed to maintain ecosystem function under livestock production

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Abstract

Recent and long-term climatic trends suggest the Colorado Plateau, USA is undergoing more frequent and extended periods of drought and heat, reducing available forage quantity and quality, and contributing to rangeland degradation. Rarámuri Criollo (RC) cattle, a heritage breed from Mexico, have been shown to exhibit behaviors that may be well-adapted to dryland ecosystems, including the Chihuahuan Desert and Colorado Plateau, and could represent an adaptation to address climate change. Such behaviors include ranging farther from water, eating a broader diet, and navigating more rugged terrain than conventional breeds. These behaviors could increase forage availability relative to conventional breeds while reducing negative impacts on rangeland resources. Here we investigate the potential of RC cattle to maintain ecosystem function under livestock production in the Colorado Plateau, a resource-limited environment. At the Dugout Ranch, located in San Juan County, UT, we are tracking the movement of 20 Red Angus (RA) and 20 RC cows using GPS collars and pedometers and are monitoring their impact on ecosystem services (e.g., erosion prevention and soil stabilization). Contrary to our predictions, we found that in the growing season, RC appear to have more concentrated landscape use (i.e., have more high use intensity pixels) than do RA. Moreover, though we expected RC to take more steps than RA, we found no significant difference between the average number of steps taken each day by RC and RA. Recent work examining RC and RA movement data from five locations, including the Dugout Ranch, suggest that differences between RC and RA space-use and movement behaviors are greatest in the dormant season; as such we are continuing to investigate how these behaviors differ across seasons. The results of this study could provide opportunity for ranchers on the Colorado Plateau to implement adaptive solutions to challenges posed by a changing climate.

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beefSD: Exposure to a holistic view of the beef cattle industry helps beginning producers increase operation sustainability over time

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Abstract

A major challenge to sustaining U.S. farms and ranches is aging agricultural producers. The average age is now 57.5 years, an increase from 50.2 years in 1978 and a continuation of the long-term trend. South Dakota State University Extension provides a 2-year educational program called “beefSD” to increase opportunities for and success of the next generation of beef cattle producers. The purpose is to provide producers with a holistic view of the beef industry, an appreciation for utilizing adaptive management to respond to challenges and opportunities, and skills to assess and manage factors that influence overall operation sustainability. The curriculum has four major components: 1) in person workshops, case studies, interactive webinars, and homework 2) out-of-state learning experiences, 3) ranch to rail program, and 4) networking and mentoring. Since its inception in 2011, beefSD has included five classes of participants, with Class 6 started in Fall 2022, reaching over 150 producers that represent over 90 operations. To date, alumni have indicated that what they learned in beefSD is the driving factor for 50% of the changes they have made to their operation. Over 75% of alumni have increased profitability and herd size. Similarly, over 75% of alumni have adapted new marketing strategies and increased their conservation and resource management efforts. Overall, beefSD is a strong example of the impact an Extension program can create for producers, particularly one focused on providing a holistic view of the beef cattle industry and the management skills needed to increase operation sustainability. It is widely applicable and could be adopted in other states or for other commodities and resources.

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Achieving the promise of landscape demography with drone-based measurements of sagebrush demographic rates

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Abstract

As anthropogenic disturbances increase in size, frequency, and intensity, spatial forecasts of plant population growth rate will aid restoration efforts. Measurements at the level of individual plants underlie current models for plant population dynamics that could be applied to forecast ecosystem recovery. However, there is a scale mismatch between the large spatial extent of many disturbances and the limited spatial extent of field plots used to monitor individual plants. Novel remote sensing data from unoccupied aerial systems (UAS) could resolve this scale mismatch by providing imagery with fine enough resolution to detect individual plants across large spatial extents. Our research focuses on spatial population dynamics of big sagebrush, *Artemisia tridentata*, a species with high conservation value in the American West. As wildfires decimate sagebrush habitat, landscape recovery depends on whether big sagebrush can recolonize disturbed areas. However, like most low-statured plants, our understanding of big sagebrush demography is almost entirely derived from meter-scale field plots, limiting extrapolation to larger scales. We will demonstrate a workflow to quantify individual size and demographic rates of sagebrush plants from UAS imagery. Applying our methods across twelve landscapes undergoing post-disturbance recovery, we correctly detected 89% of sagebrush plants >10 cm in height. Building off this result, we are able to replicate field measurements of growth, survival, and reproduction from aerial imagery. The capacity to measure performance of individual plants at landscape extents will boost restoration and conservation of sagebrush in rangelands threatened by large-scale disturbance.

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Improving Grazing Prescriptions: Comparison of forage production estimates from traditional plot-based methods and small unmanned aerial systems (sUAS) imagery classification methods.

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Abstract

Estimating standing crop of forage is the basis for developing ecologically-focused grazing prescriptions, such as conservation grazing, fuels reduction projects, or weed removal/reduction, riparian or meadow management, etc. Traditional methods for estimating standing crop include visual obstruction methods and plot-based methods involving a percentage of plots clipped and weighed. The harvest methods are more applicable to sagebrush steppe rangelands than the visual obstruction methods, but they are resource intensive procedures. We collected standing crop data at three previously-burned Sagebrush Steppe sites in Nevada, using the harvest method, clipping all herbaceous plant species within 24 individual 1 m^2 plots at each of three study sites. We collected 1 cm - 1.5 cm resolution imagery at six 30 m x 30 m plots at each site using a multispectral sensor (R,G,B, Red edge and NIR) mounted on a small unmanned aerial system (sUAS). We also collected 3 cm - 6 cm resolution imagery for each study site. We estimated standing crop for the three study sites using three different methods. In the first, we interpolated standing crop data from the traditional harvest method across each study site. In the second method, we interpolated our standing crop data across three strata (low, medium, and high cover levels) from the annual herbaceous cover estimates (USGS 30m resolution data). For the third method, we developed a workflow utilizing the harvested plots and Daubenmire cover plots to train the classification of the combined spectral bands and canopy height models. We then used a predict function to estimate the standing crop for each study site. We evaluated the performance of the three resulting models using k-fold cross validation. We discussed the implications of choosing each of the workflows for estimating standing crop and developing grazing prescriptions using these methods.

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Capitalizing on the “lemons” beaver create: How to turn a riparian restoration project into lemonade

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Abstract

Riparian degradation caused by stream incision is a pervasive problem throughout the American West and can lower water tables and cause streams to become disconnected from their floodplains, reducing riparian plant growth that livestock and wildlife rely on. Low-Cost, Low-Tech Structures (LCLTT) such as Beaver Dam Analogs (BDA) and Post Assisted Log Structures (PALS) have been utilized in western parts of the U.S. to restore degraded streams and to encourage recolonization by beavers; however, they have yet to see widescale adoption in the Great Plains. A section of Cottonwood Creek on the South Dakota State University Cottonwood Field Station (Phillip, SD) was chosen as one of four sites to install BDAs and PALS to investigate the effects of LCLTT structures for riparian restoration on forage production, plant communities, and soil moisture in western South Dakota. Ten PALS were installed on Cottonwood Creek in July 2022; one month after installation high flows breached a naturally occurring beaver dam >1 mi upstream. The ensuing surge of water destroyed five of the ten PALs. Unexpectedly, the remaining structures slowed and impounded enough water to entice beavers to begin colonizing one of the experimental stream reaches within a matter of days – this was hypothesized to take years due to the severity of stream incision. Although structures were destroyed with the high flow, the recolonization of beaver to Cottonwood Creek was encouraging. This complicates investigations into understanding the direct impacts of BDAs/PALS on vegetation and soil moisture. The 2023 field season will allow us to see the full effects of beaver recolonization 1 year after they arrived. We encourage other researchers to “make lemonade” out of the lemons that beaver create in riparian restoration projects – they act as Mother Nature’s first engineers.

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Shadows and Sagebrush: Ameliorating shadow effects in small unmanned aerial system (sUAS) imagery when estimating biomass and cover in Sagebrush Steppe systems.

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Abstract

Shadow minimization during imagery acquisition is the standard protocol for photogrammetry missions using small unmanned aerial systems (sUAS). Standard methodology for shadow minimization is to perform imagery acquisition within a window of two hours either side of solar noon. There are several reasons why imagery may need to be acquired outside of the standard time window, or during winter when shadows cannot be minimized even when acquired within the recommended window. We applied three different methods for shadow minimization on two different Sagebrush Steppe plots, one grass-dominated and one shrub-dominated. We evaluated the differences in producer's and user's accuracy and overall kappa between cover classes in our classification scheme and variability in biomass estimates for each of the shadow minimization techniques. We present a final recommended workflow for minimizing effects of shadows when deriving plant cover and biomass estimates from sUAS imagery acquisitions.

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Exploring the status of historical greenstrip seedings containing forage kochia (*Bassia prostrata*) in northern Nevada

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Abstract

In 1985, a roadside program of planting fire resistant species that could retain moisture throughout the fire season (called “greenstripping”) was initiated in Idaho by the Bureau of Land Management (BLM) to help slow wildfire spread in rangelands. Originally, these greenstrips were seeded with introduced grass species. However, by the 1990s, a new introduced semi-shrub cultivar became the more preferred species for these plantings due to its low stature, forage production, and its ability to resprout after fire. Forage kochia (Bassia prostrata) quickly grew in popularity and was included in many seedings. In fact, we found that over 1.5 million acres have been seeded with forage kochia by the BLM in four states: Idaho, Nevada, Oregon, and Utah, with Nevada exceeding in the acres and number of projects seeded with this introduced cultivar. However, little research has been done to examine its current status. Therefore, we surveyed fourteen historical (1992-2011) greenstrip plantings that included forage kochia across northern Nevada within a variety of ecological sites. We compared the cover of forage kochia, seeded perennial grasses, and cheatgrass across these different greenstrip seedings, asking how cover differed among planting years, ecological sites, and across different ecological sites in the same seeding year. Our findings suggest that, in Nevada, forage kochia cover did not decrease with the age of the seeding. However, the cover of seeded grasses was higher in more recent seedings. When comparing eight seedings completed in 2003 across four ecological sites, we found that greenstrips in the ecological site with the highest precipitation zone (10-12”) were the most successful, including highest cover of forage kochia and seeded grasses, and lowest cover of cheatgrass. Together, our findings suggest that ecological site may be more important than planting year in predicting long-term success of greenstrip seeding with forage kochia in Nevada.

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Development of an allometric equation for biomass estimation of ‘Immigrant’ forage kochia (*Bassia prostrata* (L.) A.J. Scott)

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Abstract

Forage Kochia (*Bassia prostrata* (L.) A.J. Scott) is an introduced perennial semi-shrub that is well suited to drought resistant conditions and serves as important forage for sheep, goats, cattle, and other grazing animals. Long-lived, it is native and most abundant in Kazakhstan, Uzbekistan, and Kyrgyzstan, though its range extends throughout Central Asia and now the Western United States. To date, there has not been an allometric model developed for ‘Immigrant’ forage kochia, a variety released by the USDA in 1984 from the subspecies *virescens*. Allometric models use predictor variables to allow for the estimation of aboveground biomass, without having to repeatedly destructively harvest the perennial semi-shrub. Most shrub allometric models use crown volume estimates or combinations of crown volume predictors such as crown diameters, circumference, or crown height to develop regression models of aboveground biomass. We collected two perpendicular crown widths and the crown height to the nearest centimeter on 27 forage kochia plants of a variety of age/size classes in Santa Rosas Mountains near Paradise Valley, Nevada during June and July of 2021 and 2022. We then harvested each of the plants at the ground level and weighed the plants before and after drying. Our regression equation is presented and we discuss the unique growth form of grazed forage kochia and the challenges this growth form presents for biomass estimation. Our allometric model for forage kochia can improve aboveground biomass estimates of forage kochia derived from remote sensing data, including terrestrial laser scanners and small unmanned aerial system (sUAS) captured imagery.

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The International Network for Seed-based Restoration (INSR): A thematic section of the Society for Ecological Restoration

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Abstract

The International Network for Seed-based Restoration (INSR, ser-insr.org), a thematic Section of the Society for Ecological Restoration, seeks to highlight seed-based needs for ecosystem restoration. Ecological restoration is a growing sector with annual global costs exceeding a trillion dollars and seed collection and cultivation industries as important components. INSR members and partners include professionals, scientists, students, and representatives of industry, government and non-governmental organizations. Current participation includes more than 600 members in 60 countries. Major goals are to: 1) advance public education, policy, and awareness of the global need for native plant seed research, conservation, and use; 2) sponsor a forum to promote mutual learning among stakeholders; 3) promote our international standards for native seed; 4) serve as an emergency expert panel to address germplasm, biodiversity, conservation, seed farming and restoration issues; and 5) provide examples of best practices in seed-based restoration. To accomplish these goals, INSR sponsors conferences, workshops, field trips, webinars, and forum discussions. Check our website (ser-insr.org). We seek to provide information on seed-based restoration, and we welcome news items, event notices, and links to databases, publications, and tools. Share your knowledge with others working in similar systems globally (contact: info@ser-insr.org). You can also join INSR by checking the INSR box next time you renew your SER membership. We look forward to meeting you!

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Placing Fall-harvested Wyoming Big Sagebrush Plants to Catch Snow and Provide Seed for Creating Sagebrush Islands.

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Abstract

The re-establishment of sagebrush (Artemisia spp.) following wildfire has been difficult, especially in the 8 to 12-inch precipitation zone. We investigated the use of late-fall harvested, whole sagebrush plants, laden with seed and staked to fixed locations (i.e., cache seeding treatment), as a sagebrush seeding technique on burned areas. In November of 2016 and 2017, respectively, we established three study sties. Cache seeding, traditional broadcast seeding method (BSM), control treatments occurred at each site, with five plots per treatment. Cache treatments in 2016 were staked to prevent any movement by the cut sagebrush. The 2017 cache treatments attached the cut sagebrush to a t-post with a single wire, allowing lateral wind-driven movement. The first growing season (2017) followed a wet winter and cache treatments and had substantially more seedlings and greater seedling survival than the other treatments. By October there were 86 seedlings per 15-m2 cache plot: two orders of magnitude greater than for the BSM and control treatments. In the second growing season (2018), almost all cache plots (13 of 15), across all 2016 sites, had at least one sagebrush seedling. Two plots had over 300 seedlings. Only one of the 30 BSB or control plots had any seedlings (n=2). Following a dry winter (2017-18), seedling counts on three additional study sites were much less than those in the first growing season of the plots established in November 2016. It is unclear whether the drier winter, the modified cache treatment (with obvious scour marks), or more likely, a combination of the two resulted in fewer sagebrush seedlings. The cache seeding technique has the potential to rapidly establish sagebrush islands. The full range of conditions (precipitation, snow cover, soils, current herbaceous vegetation composition) for which this seeding approach can be successful remains unknown, but warrants further study.

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Phased post-fire rehabilitation effects on plant community and soil characteristics in the Great Basin.

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Abstract

Post-fire rehabilitation treatments in the Great Basin often include a primary phase of herbicide application followed by seeding. However, the efficacy of these phased treatments is often unknown. We examined how herbicide-seeding rehabilitation treatments altered the post-fire successional trajectories of plants and biological soil crust (biocrust) after the Strawberry Fire in eastern Nevada. Herbicide addition, seeding rate (9.5 & 13.5 lbs acre-1), and seeding method (hand seeded and pipe harrow) were manipulated inside the burn coincident with unburned controls and monitored for three years post-fire. Cheatgrass cover remained consistently low in unburned plots over three years. Within the burn, cheatgrass cover was comparable to unburned levels until year three, where cover increased 83% over a single year. Overall, seeding rate was an unimportant factor affecting post-fire community composition; however, seeding method and herbicide application affected plant community composition and soil properties. Soil disturbance created by pipe harrow resulted in significantly lower biocrust cover three years post-fire. Total cover was reduced with herbicide addition, and this effect was confounded by seeding method to further reduce total cover, indicating an herbicide effect on seeded species. These results highlight complexities between rehabilitation effort and the resulting community characteristics achieved to meet management objectives.

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Repeat Photography in the Santa Rosa Mountains, North-central Nevada.

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Abstract

Repeat photography is a time-honored approach for understanding vegetation change, from point to landscape scales. When coupled with information about past land use, disturbance history, and climatic patterns and trends since the date of the original photo it's possible to develop an understanding, to some degree, for the cause or causes of vegetation change across time. The magnitude of change often is substantial but poorly documented: few remain in one location long enough to grasp the degree of long-term changes. Staff with the Santa Rosa Ranger District assembled thousands of photos taken on the District since 1915 and scanned them into a digital database. While many are not suitable for a repeat photo study upwards of 350 to 400 taken between 1915 and 1992 provide enough identifiable features to warrant a repeat photo. The oldest phots, while few in number, clearly show severe rangeland degradation upon creation of the Humboldt-Toiyabe National Forest in 1911. At that time, livestock numbers on just the Santa Rosa Ranger District (approximately 310,000 acres) numbered 150,000 or more sheep, 60,000 cattle, and 1,500 domestic horses, for a 5.5-month spring through fall grazing season. Across the past several years, over 300 repeat photos have occurred across all vegetation types, and all elevations. Since 1911 livestock numbers have declined by 95%, and rest or deferred rotation systems replaced the original season long approach. The spatial extent of aspen has increased, as has the understory component. Woody and herbaceous riparian vegetation has expanded and important mountain shrub species have increased. Bare-ground and erosion have decreased. Perennial grasses generally have increased, but invasive annual grasses remain a problem at the lowest elevations. Despite historic degradation, since the 1970's, riparian areas and mid and upper elevation bunchgrass-sagebrush plant communities have recovered well following fire and/or catastrophic flooding.

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Water Quality and Quantity Programs of USDA-NIFA Supporting Rangeland Science and Management

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Abstract

The U.S. is committed to the proper management of agricultural practices and improved efficiency of agricultural water use to protect water quality and increase water and food security (U.S. Global Water Strategy, 2017). USDA-NIFA will provide competitive support to improve water science, management and technologies, water conservation and water use efficiency; promote common data exchange formats and access to data for decision-making, improve forecasting and model water related systems. Rangeland dominated ecosystems represent an important focus of NIFA's water science portfolio. Practically, USDA-NIFA seeks both research and integrated (research + Extension or education) proposals to: a. improve the freshwater delivery (both groundwater and surface water) from rangeland watersheds and minimize the nutrient flux from grazed rangelands by substituting the use of other more appropriate watershed management technologies, rangeland management practices and/or other water sources for irrigating complementary pasture and/or cropland (e.g., recycled wastewater, brackish groundwater, agricultural return flow, and produced water from industry) while retaining appropriate soil health (managed salinity, adequate infiltration) and eliminating accelerated erosion; and b. improve nutrient management and reduce nutrient load to surface or groundwater. Water Quantity and Quality (A1411) supports foundational and applied research/integrated projects to advance the scientific understanding of rangeland water and watersheds in terms of water availability (quantity + quality), soil loss, and nutrient management.. NIFA supports a broad portfolio of research to develop tools, practices, techniques and/or innovations for improving rangeland watershed condition, soil health, and water quantity and quality to benefit the resilience and sustainability of rangeland agroecosystems.

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Remote Sensing for Wildlife

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Abstract

Open Range Consulting (ORC) visited and collected data on nine USFWS Refuges across the western United States in 2022. The purpose of mapping both upland and riparian systems was to establish a baseline condition in these areas. Each Refuge also had specific concerns unique to its area, which ORC was able to specialize and focus on with the hope of providing them with useful information. The Jackson Hole Elk Refuge was one area we collected data on, specifically targeting cheatgrass. The existing publicly available tools to detect cheatgrass are not fine scale enough to detect the small measles of cheatgrass which exist at the refuge. Using Earth Sense Technology, the Refuge employees can address the cheatgrass concerns effectively before it takes a strangle hold on this incredibly important symbolic area of wildlife conservation.

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Impact of Conservation Grazing of Western Washington Prairie on Soil Quality and Forage Species

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Abstract

Most rangelands west of the Cascades in the Pacific Northwest occur on sites that historically supported native prairie. For prairie habitat protection on grazed land, conservation grazing practice (CGP) recommendations are needed that improve forage composition, soil quality, and productivity. This study assessed soil quality parameters and forage species changes in grazed and ungrazed prairie, and in response to CGPs including native forb seeding and a spring grazing deferment. Grazing treatments (CGP versus business as usual (BAU) grazing) and site management (grazed versus ungrazed) were evaluated for their effect on summer biomass, residual stubble height, and soil quality parameters including soil bulk density, soil nutrients, and soil temperature. Significantly different residual heights were observed between sites (grazed and ungrazed) and grazing treatments (CGP = 5.72 in, BAU = 2.00 in). Soil temperatures were highest at ungrazed sites and lowest in grazed sites (69.5 F in ungrazed, 67.4 F in grazed BAU, and and 65.1 F grazed CGP). Summer average daily high soil temperatures were lower and July biomass productivity higher in CGP as compared to BAU plots. No differences in soil nutrient status were observed in response to management (CGP versus BAU), but overall soil fertility was higher at grazed versus ungrazed sites. Mean soil bulk density in CGP and BAU were 1.14 g/cm3 and 1.15 g/cm3, respectively, and were not significantly different. Lastly, the percent cover of more palatable and more productive grass species increased from 4.5% to 10.2% in CGP plots. These findings suggest the potential for CGPs applied by ranchers and conservation land managers to improve soil quality, forage productivity and composition, and overall resiliency of grazed western Washington prairies.

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Mapping Percent Soil Carbon and its Change in the Riparian Areas of the Humboldt Ranch

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Abstract

The Humboldt Ranch had traditional livestock grazing from the 1800s to 2003. In 2003 unique livestock grazing management was implemented to heal riparian areas that were extremely degraded. This management change resulted in uplift of 140 miles of stream going from Non-Functioning in 2003 to Proper Function and Condition in 2022. We examined what this means in the percent of soil carbon change in these riparian areas using ground samples, current and historical remotely sensed imagery.

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Leveraging erosion models with established land health assessments to support management decisions

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Abstract

Land health assessments support management and mitigation of soil erosion that negatively impacts environmental and human health. Land managers can evaluate land health by relating qualitative and measured erosion indicators describing ecosystem attributes (e.g., ecosystem structure) to erosion evidence, such as in the widely applied Interpreting Indicators of Rangeland Health (IIRH) protocol. In contrast, erosion models such as the Aeolian EROsion (AERO) model and Rangeland Hydrology and Erosion Model (RHEM) estimate sediment transport rates and erosion risk using weather inputs, common ecological measurements, and their interactions. Comparison of model estimates to benchmarks can be used to assess site susceptibility to erosion, site stability, and land status. Integrating use of erosion models into land health assessments could promote better understanding of ecosystem function and further inform land management decisions and planning. We identify workflows and establish a conceptual basis for using model-driven (AERO and RHEM) and qualitative and measured (IIRH) erosion indicators together to evaluate land health through: 1) conducting a post hoc review of erosion indicators to determine land health; or 2) incorporating evaluation of modeled erosion indicators into the IIRH assessment process. An example from southern New Mexico clarifies application of the combined approach. We also illustrate through examples the fundamental characteristics of modelled, measured, and observed erosion indicators that users should consider during evaluations. Integration of modeled erosion indicators into IIRH will provide land health assessments that consider erosion evidence, sediment transport, and current and potential erosion risk that better inform landscape condition and management decisions.

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Effects of temperature and lunar illumination on cattle activity and distance traveled from water at night by Corriente cattle

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Abstract

During periods of high ambient temperature, cattle grazing behavior may be altered, which may require changes in management. The objective of this study was to determine the effect of temperature and lunar illumination on cattle grazing behavior at night. From June to October 2019, 21 Corriente cows were tracked in 1096 ha pasture near Prescott, AZ. Repeated measures analyses evaluated high temperature for the day and lunar illumination on activity, distance from water and the distance traveled at night. There was a non-linear relationship ($P<0.05$) between distance from water and temperature and an interaction of temperature and illumination ($P<0.05$). During the full moon cattle were farther from water at night than during the new moon, but impacts of lunar illumination were minimal on days with high temperatures. Activity at night decreased ($P < 0.05$) at higher temperatures. The interaction of temperature and lunar illumination showed that activity was higher during the full moon than new moon, but the effect of illumination was minimal during higher temperatures ($P<0.05$). There was a linear negative relationship between distance traveled at night and high daily temperature and a positive linear relationship with illumination ($P<0.05$). The interaction of temperature ($P<0.05$) and illumination showed that cows traveled farther during the full moon than new moon but increased travel during periods of greater illumination did not occur during high temperatures. At night, cattle were more active, traveled farther and used areas farther from water during periods of greater lunar illumination, such as a full moon. However, lunar illumination had little impact on nighttime behavior during periods of high temperatures when cattle where less active, travel less and remain closer to water.

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Prediction of diet nutritional quality of Brown Swiss heifers in grazing systems using Near Infrared Spectroscopy (NIRS)

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Abstract

Nutritional value of diets is a key factor for the construction of feeding plans; however, laboratory analyzes are expensive, time consuming and use dangerous reagents. Near-infrared spectroscopy (NIRS) technology allows high-precision prediction of nutritional quality at low cost and time. The objective of the study was to predict the quality of the diets of Brown Swiss heifers, grazing Ryegrass - clover – Dactylis pastures, using NIRS. Eight heifers of approximately 8 months of age (350 Kg liveweight in average) were used in Fundo Agro Kuelap, Amazonas region, Peru (2893 m.a.s.l.) classified as Tropical lower Montane Humid Forest Life Zone (bh-MBT). The diets of each heifer were collected using the manual simulation method every two months for a year, obtaining 96 samples which were dried and ground to a size of 2 mm. The nutritional parameters analyzed at the Nutritional Laboratory were total crude protein (CP) and total ash by the AOAC method; Neutral Detergent Fiber (NDF) and Acid Detergent Fiber (FDA) by Van Soest; and in vitro digestibility (IVDMD) by Tilley and Terry. In addition, spectra of the diets were taken with NIRS 2500XL (Unity Scientific, USA) in the wavelength range of 1100 - 2500 nanometers, and then these were analyzed in the UCAL Model software to make the prediction using the Partial Least Squares (PLS) regression method. The determination coefficient R2 was 0.95 for CP, 0.91 for NDF, 0.35 for in vitro digestibility, 0.83 for ash and 0.69 for ADF; the EEC calibration standard error was 0.49, 0.86, 0.38, 0.89 and 1.4 respectively. Therefore, the percentage of CP, NDF, ADF, ash in heifer diets can be predicted using NIRS technology. Since it was not possible to predict IVDMD, ADF can be used to estimate Metabolizable Energy and with the other nutritional values grazing feeding profiles for heifers will be designed.

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The Impact of High Net Worth Individuals on Communities and Rangeland Management in Southwest Montana

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Abstract

Across agriculture in the United States, a shift to absentee ownership of land is occurring. The long-held image of a traditional farmer or cowboy waking every morning to work on their land is slowly being replaced, on ranches, by wealthy individuals and corporations who hire a manager to work on their land in their absence. In the Intermountain West, rural communities are experiencing an increase of ranch sales to high net worth (HNW) individuals who are purchasing large ranches and maintaining them as working ranches. These ranches potentially provide a symbol of commitment to conservation, an investment for the wealthy, and have recently started serving as a status symbol for some. HNW individuals have the potential to impact rangeland management, as well as broader community cultural and economic processes, introducing new risks to and opportunities for ranching livelihoods. Building off a growing body of research that explores the motivations of HNW individuals purchasing working ranches in the Intermountain West and the impacts these individuals have on rural ranching communities and rangeland ecologies, I present preliminary findings from semi structured interviews and public intercept surveys of ranchers and community members in a Southwest Montana community experiencing an increase of HNW ownership of large working ranches. Preliminary findings indicate that community members are divided on the impacts and benefits of HNW ownership. Ranchers are similarly divided, some ranchers view increased HNW ownership as detrimental to landscapes and community relations, while others don't find increased HNW ownership to be harmful. This research provides insights into changing ownership patterns in the Intermountain West and the impacts of those changing patterns on rangeland management and community dynamics.

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Shifts in Sage-Grouse Arthropod Food Sources Across Grazing and Environmental Gradients in Upland Meadow Communities

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Abstract

Groundwater dependent systems are extremely important habitats for a wide variety of taxa in the Great Basin of North America. The impacts of grazing on these habitats cause shifts in resources and subsequent change in species composition. The Greater sage-grouse, a keystone species of Great Basin ecosystems, rear brood in these areas during spring and summer months, utilizing forbs and arthropods. To examine the impact of grazing on arthropod abundance in these ecosystems, seven meadows, each consisting of three distinct vegetative communities, were grazed at three intensities across three years (2019-2021) and monitored for environmental variables and abundance of arthropods during peak sage-grouse utilization periods. Additionally, the agreement of on-the-ground measurements and near-surface digital cameras (phenocams) was examined to better understand how remote sensing technologies can be used to monitor these insect abundance shifts on larger scales. Arthropod taxa abundance responded differently to grazing management and environmental variables. Coleoptera abundance during peak sage-grouse usage periods had an increase of roughly 40% in some meadows with increased grazing intensity, while Formicidae abundance saw a 22% decrease. For year-to-year environmental variability in precipitation, Lepidoptera abundance was 115% higher in the drier year, while Coleoptera was 64% lower. Near-surface cameras had varied success with predicting peak insect abundance levels. Lepidoptera and Coleoptera capture rates had strong correlations with phenological indices derived from phenocams, while Formicidae had much weaker relationships.

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Patterns and trends of BLM natural resources: 10 years of BLM AIM data in action

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Abstract

The Bureau of Land Management (BLM) is mandated by the Federal Lands Policy and Management Act of 1976 (FLPMA) to "maintain on a continuing basis an inventory of all public lands and their resource and other values". Vegetation, soil, and water in upland, lotic, and wetland systems are a critical part of these resources on public lands and provide the foundation for many other BLM-managed resources and ecosystem services including recreation, scenic values, livestock grazing, biodiversity, and wildlife habitat. Since 2011, the BLM has kept an inventory of these resources through the Assessment, Inventory, and Monitoring (AIM) strategy. The objective of the AIM Strategy is to provide a standardized monitoring strategy for assessing natural resource condition and trend on BLM public lands. The AIM Strategy provides quantitative data and tools to guide and justify policy actions, land uses, and adaptive management decisions. Here we present, for the first time, results from terrestrial and lotic AIM, as well as a summary of a pilot project of riparian and wetland AIM. Data are summarized to all BLM-managed states, and we examine how these resources have changed through time. Multi-resource analyses and reports such as this can help support and provide context to fine-scale, locally based adaptive management as well as nationally relevant resource issues such as changes in condition as a result of climate change.

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Evaluating the Insurance Hypothesis: Biodiversity and Rangeland Productivity in a Variable Environment

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Abstract

Biodiversity influences many aspects of ecosystem functioning. Increasing plant diversity increases ecosystem primary productivity and decreases its temporal variability because greater biodiversity insures that some species produce even when others fail, a concept called the *insurance hypothesis*. Thus, increasing biodiversity enhances primary production and promotes resilience. Although compelling evidence exists for the biodiversity-productivity relationship from controlled experiments, it is less certain whether biodiversity is as an important driver in natural landscapes where unpredictable rainfall and herbivory may exert profound influences on ecosystems. Our objective was to evaluate the biodiversity-productivity relationship in a semi-arid rangeland setting subject to unpredictable rainfall and long history of livestock grazing. We hypothesized that the insurance effects of biodiversity would be weaker in such a system. Our study was conducted in southern Texas (Jim Hogg County) during 2018–2022 on a 27,475-ha site (19 pastures; 154–937 ha each) where grazing pressure in each pasture ranged from no grazing (0% harvest efficiency) to moderate grazing (25% harvest efficiency). We randomly established 10 paired, 1 m × 1 m plots (1 grazing exclosure and 1 unfenced plot; 10 m apart) within each pasture using proportional allocation based on ecological site (*n* = 380 total plots). We measured plant species richness and biomass on each plot during early autumn (Sep–Oct). We used PRISM to estimate growing-season rainfall (May–Aug) within a 250-m buffer of paired-plot centroids and categorized plots according to harvest efficiency. We used multiple linear regression to evaluate the influence of plant species richness, rainfall, and grazing pressure on rangeland productivity and its temporal variability. Here we present these findings and discuss their implications from ecosystem functioning and rangeland management perspectives.

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Impact of cattle origin on enteric methane emissions and animal performance in stocker steers grazing extensive semi-arid rangelands

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Abstract

In the United States, animal agriculture accounts for approximately 3.8% of greenhouse gas (GHG) emissions and enteric methane (CH4) production accounts for approximately 30% of total CH4 emissions (EPA, 2021). Current beef industry life-cycle assessments indicate that approximately 60-70% of the industry's GHG emissions and 70-80% of the industry's CH4 emissions are from grazing systems, prompting a need for mitigation strategies focused in grazing environments (Rotz et al., 2019). However, GHG emissions are largely unknown from cattle grazing extensive semi-arid rangelands. The objective of this study was to evaluate the impact of cattle origin on CH4 emissions and animal performance. Steers were sourced from 1) the Crow Valley Livestock Cooperative (CVLC) in Nunn, Colorado and 2) the USDA Meat Animal Research Center (MARC) in Clay Center, Nebraska. Cattle grazed the USDA-ARS Central Plains Experiment Range in Nunn, Colorado on a high productivity shortgrass steppe pasture from May to August. One GreenFeed automated head chamber system (C-Lock Inc., Rapid City, SD) was utilized to measure CH4 emissions on 12 steers (BW = 305 ± 38 kg; 9 CVLC, 3 MARC). Steers were individually weighed at 28-day increments throughout the grazing season to calculate average daily gain (ADG). Statistical analysis was conducted in R with the fixed effect of origin. Daily CH4 production ranged from 153 to 238 g CH4/day. CH4 production was greater for steers originating from CVLC ($P=0.044$) but CVLC steers had a lower CH4 emissions intensity (g CH4/kg of body weight gain; $P=0.033$). CVLC steers had a greater ADG than MARC steers ($P=0.0064$). The results of this study indicate that cattle origin alters CH4 emissions and animal performance in stocker steers grazing extensive semi-arid rangelands.

Keywords: rangeland, grazing, enteric methane, cattle

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Grazing intensity and fire frequency effects on plant species and community characteristics in tallgrass prairie

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Abstract

Disturbances such as fire and grazing enhance plant biodiversity and maintain sustainable species composition in grasslands. Yet, when these disturbances increase in intensity, they may negatively affect vegetation. Management strategies such as patch burn grazing (PBG) use prescribed burns to implement a naturally rotating fire and grazing interaction across the landscape. Currently, we have limited information about how the effects of grazing intensity are altered within this mosaicked landscape of fire. During the growing season of 2021, we implemented four levels of grazing intensity: no grazing, ambient grazing (cattle stocked at 3.2 ha per pair), heavy grazing (ambient + 50% clipped), and severe grazing (ambient + 100% clipped) within a long-term PBG experiment in tallgrass prairie (Konza Prairie Biological Station, Kansas). The PBG system is divided into three watersheds, each undergoing a prescribed burn every three years in a rotation with the annual burning and grazing (ABG) pasture as the control. Here, we address two overarching questions: how does grazing intensity and fire frequency interact to affect biodiversity, plant phenology, and community composition, and how does the legacy effect of grazing alter these variables across fire treatments? Heterogeneity of vegetation and soil moisture was substantially greater in PBG treatments compared with ABG. Plant species richness and evenness in this system were surprisingly resistant to grazing intensity in PBG. Initial analyses of plant phenology traits suggest that severe grazing advances the natural seasonal brown down of some C4 grass species. Lastly, we used multivariate analyses to assess whole community changes to show that communities may shift after two years of grazing manipulations. We suggest that heterogeneity created by PBG is a strong stabilizing factor for plant communities at large spatial scales. PBG and other management strategies that focus on maintaining heterogeneity are likely to result in sustainable landscapes.

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Plant community response to changes in grazing and precipitation timing in the Shortgrass Steppe

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Abstract

Plant regrowth after grazing is important for both long-term sustainability of important forage species in rangelands, as well as providing potential regrazing later in the growing season. Two major components drive plant regrowth after grazing: (1) timing of grazing, (2) rainfall inputs into the system. Rotational grazing may provide an opportunity for producers to adapt to temporal and spatial variation in rainfall by utilizing observations of green-up in different pastures post rainfall. However, as climate change continues to alter rainfall variability, and in turn increases the frequency of extreme rainfall events (deluges), we must improve our understanding of how the timing of grazing and occurrence of these extreme events control plant regrowth This study was conducted at the High Plains Experimental Range in NE Colorado as part of the Collaborative Adaptive Rangeland Management Project (CARM). The purpose of CARM is to compare rotational grazing management to traditional season-long grazing on vegetation structure/composition and wildlife habitat, while remaining profitable. Working within the larger project we established plots in six rotational pastures to have early, middle, and late grazing pressure. We then added grazing exclosure cages to each plot to prevent grazing, except during designated time periods. Throughout the season, non-invasive biomass estimates were taken using pinframe measurements to determine the response of plants to grazing and precipitation. At the end of the season all plots were clipped for remaining biomass. Preliminary results suggest that additional rainfall in the form of a deluge increases plant regrowth, grazing negates those positive benefits. With this data we will be able to determine how biomass fluctuated within the season and evaluate how the plants were able to recover following grazing disturbance. This research can aid land managers in rotational grazing decisions within the growing season, while also considering the forage availability for following year.

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Prairie dog burrow and colony mapping from unmanned aircraft systems (i.e., drones)

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Abstract

Monitoring prairie dog colonies is critical for managing rangeland health and productivity but is challenging and expensive to conduct on the ground. We assessed whether imagery collected from a fixed-wing Unmanned Aircraft System (UAS; i.e., drone) could be used to accurately map individual prairie dog burrows and entire colony extents. The fixed-wing UAS allowed for relatively long and extensive flights, and we conducted the study across approximately 2,750 acres in NE Colorado covering active and recently active colonies of black-tailed prairie dogs, as well as areas without recent activity. We used a state-of-the art image classification algorithm (DeepLabv3+, a deep convolutional neural network by Google©) to detect individual burrows. We trained the algorithm with different combinations of RGB, multispectral and digital surface model image layers at progressively coarser spatial resolutions (2 – 30 cm) to determine the most effective and efficient flight parameters for monitoring. Precision and recall were 81% and 87%, respectively, using the finest spatial resolution (2 cm) and the correlation between predicted and observed burrow density was > 0.96. Misclassification of burrow-like features (e.g., anthills) was low (< 15%) and most of the missed burrows had below-average activity based on ground surveys. Burrow detection accuracy declined as imagery resolution increased beyond 5 cm, but remained acceptable up until about 15 cm, at which point it dropped considerably. Using 5 cm imagery, prairie dog colony boundaries could be delineated from heatmaps of burrow density with high correspondence (> 70%) to ground mapping of active colony extents. Burrow density was also positively related to the duration of colony existence. Result suggest that drone imagery can be used to map colony boundaries and acreage, and to help characterize within-colony variability. Drone imagery may offer new options for broad-scale prairie dog management, though image processing timelines still limit near-real-time monitoring applications.

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Exotic annual grass invasion and grazing across Northern Great Basin rangelands: a cross-scale perspective

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Abstract

Exotic annual grasses are an increasingly widespread management challenge throughout Great Basin rangelands: displacing native biodiversity, threatening forage availability for livestock and wildlife, and fueling more frequent and catastrophic wildfires. Geographic approaches to managing annual grasses depend on understanding which drivers underlie vegetation heterogeneity at regional vs. local scales, and how cross-scale interactions mediate responses. Although many predictors of annual grass prevalence have been identified, there remains substantial uncertainty about what makes some sites more resistant to invasion than others, and particularly how cattle grazing interacts with environmental drivers. Here, we conducted a large-scale field survey of vegetation plots in sagebrush rangelands across Oregon and Idaho, encompassing burned and unburned grazing allotments, to better understand how exotic annual grasses and their native perennial competitors respond to fire, environmental factors, and grazing pressure across and within landscapes. In preliminary results, annual grass cover was on average just as high in unburned as burned sites, indicating that the annual grass problem is not limited to the aftermath of fire. At both regional and local scales, temperature was a major driver of annual grass cover; annual grasses increased at higher mean annual temperatures and lower elevations regionally, and higher heat load index locally, while perennial grasses showed opposite trends. Annual grass cover was especially high under a combination of high temperatures and heavier grazing pressure, while more grazing at cooler temperatures was instead associated with lower annual grass cover. Future research should further evaluate mechanisms underlying contingent responses of annual grass dominance to grazing across different landscapes, such that managers can leverage such knowledge to address the annual grass problem in a changing world.

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Upland soil carbon pools: sampling, mitigating costs, and defining carbon distributions across large landscapes.

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Abstract

Soil carbon, the ever-present elephant in the room is very costly and time consuming to address. Understanding its distribution across large landscapes can complicate this problem even further. To address these issues Open Range Consulting had mapped dominant landcover very accurately (r2 = 0.79) across the Humboldt ranch in northeastern Nevada (~370,000 acres). Across the dominant landcover types 323 soils samples were collected. Organic carbon content was assessed for a subset of these samples in a soil lab, while every sample was scanned with a handheld spectrometer. Making the link between the lab samples and their spectrometer reading helped us to reduce lab costs and estimate carbon content throughout all the samples and assign generalized carbon content to Landcover types across a large landscape.

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Rinker Rock Creek Ranch: Collaborative rangeland management, research, and education

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Abstract

University of Idaho's Rinker Rock Creek Ranch (RRCR) is a collaboratively managed cattle ranch and research station where research, education, and conservation occur. Located in the Wood River Valley of central Idaho, RRCR includes 4200 ha of high-quality rangeland and 4450 ha of Bureau of Land Management and state grazing allotments. This property, unique within the academic sector, hosts diverse projects that can help inform decisions made by land managers about how people live, work and recreate on rangelands across the Intermountain West. The ranch helps fulfill the University of Idaho's land-grant mission as we continue to educate Idaho citizens and connect research with our industries and communities. An advisory board that includes representatives from The Nature Conservancy and the Wood River Land Trust, two nonprofits that were instrumental to the property's acquisition, collaborates with the university to provide management direction. The Advisory Committee includes representatives from eight organizations and three supporting federal agencies. This collaboration allows for a live demonstration of how conservation and sustainable ranching can work together to provide healthy landscapes for future generations. Several representative research, management, and education projects taking place at the ranch will be discussed.

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Long-term Impacts of Drought in the Southern San Joaquin Valley

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Abstract

Drought is a frequent occurrence across the western U.S., making it a common topic for research and outreach for rangeland managers. In the past 10 years, the southern San Joaquin Valley has experienced two severe droughts where precipitation received was less than 50% of normal; the water years of 2013-14 and 2020-21. In the 2013-14 water year there was almost zero germination of annual grasses on some low elevation rangelands.

Long-term mean rainfall for Bakersfield is 6.09 inches and the long-term mean for Visalia is 9.97 inches. Analysis indicates that the long-term mean (1926 - 2022) is not significantly different from the 20 year precipitation mean. However, anecdotal accounts from long-time residents and ranchers illustrates larger changes on the landscape that could be attributed to drought. For example, a spring going dry for the first-time in memory on a fifth-generation ranch or a pond going dry that used to be stocked with fish all summer. One notable change in the valley is the relative scarcity of the infamous ‘Tule fog’.

Ten years of forage production data will be presented in conjunction with a discussion of corresponding rainfall amounts and patterns. Preliminary results from a study tracking oak vigor and mortality will provide perspective on potential landscape level ecological impacts.

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Factors affecting seasonal defoliation patterns by cattle in heterogeneous grassland

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Abstract

The hierarchical foraging model of grazing distribution and defoliation pattern integrates different spatio-temporal scales and biotic and abiotic factors. We aim to identify biotic and abiotic factors affecting defoliation patterns of cows grazing a heterogeneous grassland at different spatio-temporal scales. We assessed the defoliation pattern (grazing probability and intensity of defoliation) in four paddocks (10-14-ha each) of a replicated, randomized experiment managed under high and low grazing pressure. We used 20 x 20-cm permanent quadrats nested in 50-m fixed transects within each paddock. Grazing events and intensity of defoliation of thirteen dominant species were assessed weekly during March-April (summer-autumn), August (winter) and October-November (spring), 2017, in a native grassland in north-eastern Uruguay. Paddock and quadrat biomass and height as well as the species proportion to total quadrat biomass, species leaf dry matter content, specific leaf area, leaf tensile strength, and leaf width were assessed seasonally. Regression trees were created to identify biotic and abiotic factors affecting seasonal species defoliation pattern. Biotic factors included paddock biomass, quadrat biomass, quadrat species proportion, herbage accumulation, stocking rate, herbage allowance, leaf traits and average cows body condition score as biotic factors. Abiotic factors included distance to water and shade of each transect and quadrat. The summer-autumn defoliation pattern of species was most affected by quadrat biomass, body condition score, species leaf dry matter content and tensile strength. During winter it was affected by paddock, quadrat and species biomass, and distance to shade, while distance to water and shade and species leaf dry matter content, tensile strength and width affected spring defoliation pattern. We found that factors affecting defoliation pattern shift along seasons. Cows integrated information of different spatial scales, not following a hierarchical pattern, and adjusted grazing intensity according to leaf traits mainly in summer-autumn and spring, while in winter only considered quantity-related factors.

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Biology, Ecology, and Use of Forbs in Restoration

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Abstract

Repeated fires and other disturbances have depleted native seedbanks in parts of the Great Basin, making active restoration necessary to recover native plant communities and ecosystem resiliency. Native forbs are important to sustaining pollinators, wildlife, and ecosystem function in Great Basin ecosystems, but their use in restoration has been limited. Lack of forb seed, high forb seed costs, and limited guidance for producing or seeding forbs are often cited as reasons for not including them in restoration.

The Great Basin Native Plant Program (GBNPP), an extensive, multi-disciplinary effort including collaborators at federal and state agencies, universities, state seed testing and certification agencies, and the private sector native seed industry, has improved our understanding of the biology and ecology of western forb species, particularly as it relates to their successful use in revegetation. Information gathered in this 20+ year effort, other available literature, and practical experience is being synthesized in an online book, Western Forbs: Biology, Ecology, and Use in Restoration.

Today the book includes 40 chapters that synthesize published and unpublished research, data, and protocols useful to seed collectors, growers, practitioners, and land managers looking to increase the supply and use of appropriate native forb seed to restore Great Basin ecosystems.

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Post-fire recovery of native and introduced plant species across an elevation gradient

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Abstract

Millions of US dollars are spent annually on ecosystem restoration following wildfires in order to restore critical ecosystem services. However, non-native species that invade following fires can be a major challenge for establishing desired native species, especially along environmental gradients. Understanding natural revegetation potential of a site is therefore critical for maximizing dollars spent on restoration, prioritizing key species that do not return following a disturbance like fire and understanding the interactions of native and non-native species along environmental gradients. In this study, we monitored natural revegetation of native desirable and non-native invasive species following a 2012 wildfire in the sagebrush steppe along an elevational gradient. Five sites were selected for each elevation (7 elevations x 5 sites = 35 total sites) and plant density was measured in 2014, 2015 and 2016 for all species. We used a generalized linear mixed effects model with a negative binomial distribution to assess plant densities with fixed effects of elevation and year, and a random effect of aspect. We found that native desirable species had higher densities at higher elevations (5500-7000 ft, $p < 0.001$), and this trend was particularly true for native perennial grasses (6000 ft, $p = 0.015$; 7000 ft, $p < 0.001$). Conversely, non-native species had lower densities at high elevations (7000 ft, $p = 0.007$), which was most apparent in the exotic annual grasses (6000 ft, $p = 0.012$; 6500 ft, $p = 0.035$; 7000 ft, $p = 0.009$). A year effect was most apparent with the exotic annual grasses wherein high precipitation in the winter of 2015-2016 likely drove higher emergence across all elevations (2016, $p < 0.001$). This study provides evidence to guide land management decisions on areas to prioritize post-fire restoration efforts.

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Monitoring Species Trends Across the Texas Tech University Native Rangeland

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Abstract

The Texas Tech University Native Rangeland (TTUNR) is nearly 150 acres of remnant shortgrass prairie that supports ecological research and teaching opportunities for students, staff, and faculty. Previous studies on the TTUNR have focused on measuring and tracking the diversity and distribution of various plant species over time with a particular focus on invasive and noxious species. Regular plant surveys have been completed at a set of nine sites on the rangeland since 2016. , We plan to consolidate and standardize the data from these sampling efforts and analyze which key species have changed significantly in distribution and population size. We anticipate that the data will reveal significant changes in the distribution and amount of honey mesquite (Prosopis glandulosa), Mexican feathergrass (Nassella tenuissima), Russian thistle (Salsola tragus), and blue grama (Bouteloua gracilis). We expect honey mesquite, Mexican feathergrass, and Russian thistle have increased and blue grama has decreased. This analysis will be the foundation for determining and critically evaluating long-term trends of species on the TTUNR, as well as promoting and supporting further ecological and ecophysiological research into resource utilization by various species and interspecies interactions.

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Native Grassland Restoration in the Edwards Plateau Ecoregion of Texas

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Abstract

Developing successful restoration techniques for native plant communities in disturbed landscapes is critical for conservation of rapidly changing biomes globally. Restoring native grasslands is often a target of restoration efforts because grasslands have experienced greater declines in their historic distribution than many biomes around the world. Although region-specific restoration techniques exist throughout the North American Great Plains, there has been limited research in the Edwards Plateau ecoregion of Texas, where semi-arid rangelands have experienced decades of degradation and loss of native herbaceous vegetation communities. In this research, combinations of restoration techniques were tested to assess their efficacy in promoting native grassland vegetation restoration within retired agricultural fields in Menard County, Texas, USA. Fields were selected for experimentation based on brush encroachment status and soil type. Seventy-two 0.04 ha experimental units were randomly assigned one of two site preparation treatments (disking or control), one of three native seed mix treatments (high diversity [27 species mix], low diversity [9 species mix], or control), and one of two herbicide application treatments (glyphosate [Roundup PowerMAX® II Herbicide applied at a rate of 1.68 kg active ingredient/ha] or control) using a split-split-plot arrangement of factors. Experimental units were monitored in permanent quadrats where plant species composition and density were measured during the spring and fall seasons for two years (2021-2022). Eighteen seeded species were recorded during the three sampling periods. Current data suggest the addition of either native seed mix has not increased seeded species density (0.49 plants/0.25 m^2) beyond what the seed bank offered in the controls (0.50 plants/0.25 m^2). Results from this research will contribute to the development of region-specific recommendations to enhance restoration success on disturbed lands in the Edwards Plateau Ecological Region of Texas.

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Nutrient availability and plant responses to fire-induced sagebrush mortality at the sagebrush steppe/mixed-grass prairie ecotone

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Abstract

Rangelands span a large range of climate and vegetation types that differ in their fire-tolerance. From the relatively wet tallgrass prairie that relies on frequent fires to maintain structure and function to arid shrublands where fires are rare. In the Mixed-Grass Prairie (MGP) the perennial herbaceous plants that dominant this system survive and recover from fires via belowground buds that survive most fires. The Sagebrush Steppe (SS) of North America burns less frequently than the MGP, and the dominant woody species (Artemesia tridentata) is often killed during fire events and must rely on seedbanks to maintain populations. At the convergence of these two ecosystems, how fires will impact plant recovery is not entirely clear. To begin answering this question, we initiated spring and fall at the ecotone boundary between MGP and SS to evaluate the impacts of fire on nutrient availability and plant recovery following this disturbance. We found that total available N in the soil was the same underneath and outside sagebrush canopies in the absence of fires. However, in fire-treatment plots there was greater N availability under the sagebrush canopies, but only in a year with above-average precipitation. Burning in the spring consistently resulted in higher N availability both under and outside sagebrush canopies, but summer fires did not alter N availability to the same magnitude. Our results suggest that both temporal and spatial patterns of N availability following fires is important to consider when evaluating the impact of fires at this ecotone boundary. We will discuss our results and their implications on plant recovery following fires at this important ecotone boundary.

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How do seeds delay? Germination and dormancy strategies of target restoration species in western US rangelands

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Abstract

Rangeland restoration often depends on seeding, but plant establishment is notoriously challenging in drylands due to arid climate and variable weather. Seed germination timing likely plays a key role in establishment dynamics. Early germination and fast growth offer one mechanism of risk avoidance while delay (via dormancy or other mechanisms) offers another, yet trade-offs in regeneration strategy yet are seldom considered when selecting species for restoration. We asked: how prevalent and variable are germination delay mechanisms across common species targeted for rangeland restoration? We screened seed germination and dormancy attributes for 50+ target species and varieties, plus two common non-native competitors, Bromus tectorum and Agropyron cristatum, for two western US arid ecoregions, the Great Basin and Colorado Plateau. We screened for seed light sensitivity, dormancy requirements, and tracked germination timing at three temperatures (6C, 12C, 18C) to investigate trade-offs and synergies in multivariate space. Preliminary analyses suggest wide variation in germination strategies. Over 50% of seedlots demonstrated some type of dormancy, while an additional 15% were non-dormant but light-sensitive. Seedlots also varied substantially in combinational delay mechanisms – from seedlots with multiple dormancy, light and temperature sensitivities to those with no delay and rapid, narrow germination windows. There was wide variation within both functional groups and species – several species with multiple tested seedlots showed varietal differences. Non-native competitors, while generally fast, also had delay mechanisms. We found that germination delay is common and variable among target restoration species in arid western US rangelands, with potential for substantial impacts on establishment and associated restoration outcomes. Standard screening protocols like the one in this study can inform seed mix choices in arid rangelands, particularly given the increasing emphasis on greater plant diversity in large-scale restoration seedings to support wildlife and ecosystem function.

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Assessing the impact of water and forage resources on sheep and goat distribution in Queensland, Australia – a case study

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Abstract

Spatial distribution of sheep and goats has received little study. Our objectives were to assess the impact of water location and forage resources on sheep and goat movements. Sheep and goats were tracked at 10-minute intervals with GPS collars in the same pasture from August through December 2019 near Longreach, Queensland, Australia. The 7,365-ha study area was subdivided into 1-ha tessellations. Fractional ground cover (FGC) and total standing dry matter (TSDM) were determined from CiboLabs remote sensing imagery, and these values along with distance to water were assigned to each tessellation. The FGC consisted of three bands: bare ground, green vegetation and non-green vegetation. All measures of FGC and TSDM were averaged across months and across the study period. Resource selection function analyses were conducted with Proc Glimmix in SAS using a negative binomial distribution and log link function. Sheep and goat presence decreased as distance from water increased ($P < 0.001$). In addition, we found sheep and goat occurrence increased in areas of higher TSDM ($P < 0.001$). Goat occurrence increased in areas of higher green vegetation cover ($P = 0.02$). Surprisingly, sheep occurrence decreased as overall green vegetation cover increased ($P < 0.001$). Both sheep and goat presence decreased as bare ground increased ($P < 0.001$). As expected, we found water availability to be a strong driver for sheep and goat landscape distribution, however vegetation availability and extent of bare ground affect grazing movements as well.

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Biocrust and nutrient additions increase vascular plant biomass of perennial rangeland grass Arizona Cottontop (*Digitaria californica*)

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Abstract

Rangeland management efforts can benefit from applying our knowledge of plant-soil interactions to facilitate best management and, when needed, ecological restoration practices. One such interaction is the influence of biological soil crusts (biocrusts) on vascular plant growth. The presence of biocrust can provide multiple ecosystem level benefits, including an increase of available plant nutrients. However, when coupled with factors that duplicate this function, such as the active inclusion of nutrient amendments or passive inputs via atmospheric deposition, the influence of biocrust on plant growth may be altered. To better understand this relationship, we conducted a greenhouse experiment to examine how biocrust and nutrient additions mediate plant germination and growth of the perennial rangeland grass Arizona cottontop (*Digitaria californica*). Using field collected soil from the northern Chihuahuan desert, we tested how the presence of biocrust and addition of nutrients (nitrogen and phosphorus) and carbon (glucose) may influence plant biomass shortly after germination, and then approximately three months after. Our results demonstrated that only 10 days after germination, nutrient additions (N and P) significantly increased biomass. After 90 days, plant biomass was greatest with nutrient additions while plants with biocrust were larger than those without. Soil nutrients did not follow the same pattern of plant biomass and there were no clear differences in extractable soil carbon or nitrogen among treatments. The outcome of greater vascular plant biomass in the presence of both biocrust and nutrient additions could have broad management implications. Identifying mechanisms to increase vascular plant biomass and growth, whether through passive biocrust maintenance or active nutrient amendments, can ultimately provide additional native range forage and thus improve rangeland health.

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Drone-based predictions of big sagebrush demographic performance across an elevation gradient

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Abstract

Ryan Wickersham

Abstract

Climate change is threatening rangeland ecosystems, including increasing frequency of extreme weather, wildfire, and drought. Identifying which native plants are likely to be resilient to these ongoing changes is crucial for developing climate-smart restoration plans. Sagebrush is a keystone species across western rangeland, supporting populations of native plant and animal species with structure and forage. Genetic variation underlies the wide home range of sagebrush, including resilience to varying abiotic conditions. To understand how sagebrush populations will respond to climate change, linking demographic response to weather events with genetic variation is necessary. We are applying high-resolution remotely sensed data to map sagebrush genotypes and demographic responses to drought conditions. Using unoccupied aerial systems (UAVs) we collected multispectral and RGB imagery that enabled canopy segmentation and image classification through machine learning algorithms. We applied these spatial data to quantify flower production for individual plants across our 240-acre study site in Castle Rocks State Park, Idaho. Our study includes two flowering periods in 2021, following an unprecedented heat wave early in the growing season, and 2022. Individual plants represent all three-sagebrush subspecies: Wyoming Big Sagebrush (Artemisia tri. wyomingensis), Mountain Sagebrush (Artemisia tri. vaseyana), and Basin Big Sagebrush (Artemisia tri. tridentata). We found that multispectral imagery enabled prediction of flower stalk production, with R2 >65%. Our results demonstrate significant differences in flower production between the three subspecies along an elevational gradient, including year-to-year differences that point to potential gene by environment interactions. Our work demonstrates the potential for UAS data collection to quantify how individual plants respond to weather events across landscape-scale environmental gradients, including an algorithm that can predict flower production. Our goal is to apply these results to enable land managers to identify locally adapted sagebrush genotypes that will thrive in future climate regimes.

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Saving the Steppe: Notes from the Field on Managing Mongolian Rangelands

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Abstract

Mongolia's livestock population has almost doubled in the last ten years, going from 36 million head in 2011 to 67 million head in 2021. Overgrazing is widespread and there is increasing evidence of rangeland degradation. Managing one of the world's last intact grazing land ecosystems should be a priority. Based on consulting assignments in the summer of 2022 to develop climate-resilient livestock farming systems, work in 2020 and 2021 assessing investment opportunities in the livestock sector, and considerable prior experience in Mongolia going back thirty years, this presentation will discuss some of the issues, challenges, and opportunities for improved management of Mongolia's rangelands. Encompassing 1.56 million square kilometers, Mongolia is twice the size of Texas. About 75 percent of the land area is classified as grazing land; ranging from desert to desert steppe, steppe, forest-steppe, taiga, and alpine meadows. Rangelands provide forage for livestock, habitat for wildlife, important watershed functions as well as other benefits and ecosystem services. Mongolia has a pastoral history going back at least 3,000 years. The rangelands enabled the spread of numerous nomadic groups and the rise of one of the largest land empires the world has known during the 13th century. Nomadic pastoralism that existed for millennia was transformed during the socialist period (1921-1990) and by the transition to a market economy beginning in 1991. The growth in livestock numbers, climate change, and lack of effective range management threaten to damage the foundation of Mongolia's nomadic heritage. Ecological site groups and state and transition models for Mongolian rangelands were recently developed to communicate information on vegetation changes as a basis for improved management. Innovative approaches that build on indigenous knowledge and practices, incorporate new scientific findings, and include emerging technologies are needed to engage Mongolians in designing sustainable range-livestock production systems.

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The Influence of virtual fence cues on heart rate response of cattle

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Abstract

Precision livestock management technologies have expanded significantly in recent years to include virtual fences as viable tools. As ranchers look to advance their operations, many are intrigued by the idea of replacing physical fencing with less labor- and time-intensive virtual options. Previous research has found that cattle's moderate- and long-term stress levels are not greater with virtual fence using fecal and hair cortisol, but acute stress of the virtual fence sound and shock cues has not been explored. This study examined how virtual fencing influenced acute heart rate changes of cows fitted with virtual fence collars. We equipped 20 head of mature cows with virtual fencing collars (Vence Corp). Ten head were also fitted with a Polar heart rate monitoring system (Polar Electro OY). The system consisted of a polyester/elastic band equipped with a heart rate monitor attached to two electrodes that record a constant heart rate and sync the data to a polar pro watch on the same band, storing the data simultaneously. This system was used to evaluate acute stress response to 1) hearing the warning audio cure and 2) receiving a shock. Cattle got released into a 36.3-hectare-sized pasture, and GPS data was recorded at 5-minute intervals. Heart rate data was collected at 1-second intervals for approximately 30 hrs, the length of battery life for the heart rate monitors. Based on preliminary results, minimal differences ($p > 0.1$) were observed in cattle heart rates 5 min before and after sound and shock cues from collars; however, short-term spikes in heart rate were observed. While this preliminary data suggests that sound and shock events cause heart rate increase, the increase is short-term and often returns to pre-cue levels quickly. Virtual fencing appears to provide a low-stress grazing manipulation tool for ranchers to instill in their operations.

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Long-term vegetation dynamics after 2, 4-D treatment to suppress *Wyethia helianthoides* in mountain meadows of central Idaho

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Abstract

Wyethia helianthoides (WYHE), a native perennial forb in montane and subalpine meadows of the Northern Rocky Mountains, often forms dense stands that limit forage for wild and domestic ungulates. Short-term experiments in the 1950s and 1960s demonstrated that 2, 4-D herbicide applied pre-bloom suppressed WYHE, but long-term effects are unknown. Some conservationists and land managers have expressed concerns over potential non-target effects of 2, 4-D on native forbs and plant diversity. We evaluated short-term (2 to 3 years post-treatment) and long-term (30 to 31 and 42 to 43 years post-treatment) effects of 2, 4-D application on 3 mountain meadow sites in central Idaho. In the short-term, 2, 4-D treatment replaced WYHE with graminoids, without decreasing the number of other forb species, the relative abundance of other forbs, or plant species diversity. However, treatment effects were no longer evident 30+ and 40+ years later. Also, in a separate comparison, we documented that vegetation in the treated sites 30+ and 40+ years after treatment was similar to 3 untreated sites that had been excluded from livestock grazing for > 60 years. We conclude that 2, 4-D treatment successfully achieved the short-term management objective of reducing WYHE and increasing graminoid abundance, and the 2, 4-D treatment did so without decreasing other native forbs, plant species diversity, or altering successional pathways and the potential natural plant community. Our results also suggest that WYHE dominates the historic climax plant community of some dry mountain meadow sites in central Idaho, most likely where soils are derived from glacial outwash rather than alluvium or colluvium.

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Mapping Milkweed for Monarchs

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Abstract

Open Range Consulting was hired by the U.S. Fish and Wildlife Service in 2022 to map vegetation on nine different wildlife refuges across the Western United States. In an effort to meet specific management goals, the data collection process and the maps produced from this work were unique from refuge to refuge. Officials at Seedskadee National Wildlife Refuge in Wyoming were focused on locating Milkweed, a genus of perennial flowering plants vital to Monarch Butterfly populations. Seedskadee will play an important role in the conservation and recovery of the recent ESA listed Monarch as it lies on the extreme Western edge of the butterfly's migration path. This presentation will describe Open Range Consulting's project in Seedskadee from the data collection through the creation and application of the final vegetation maps.

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Estimating shrub biomass and productivity at the Great Basin LTAR site with an unoccupied aerial system (UAS) time series

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Abstract

Rangeland productivity, both total and green biomass, is an important indicator of forage availability for livestock and wild herbivores. However, accurately measuring biomass across the landscape is challenging. Traditional methods of destructive harvesting and double sampling are time intensive and costly, and estimates from coarse field measurements (e.g., height, maximum width, perpendicular width) are limited in coverage and often don't accurately capture the complex shape and volume of the shrub canopy. Remote sensing technologies offer continuous measurements of spectral and structural characteristics across broad spatial extents, and have been shown to accurately estimate shrub volume and biomass in rangelands. In this study, we flew an unoccupied aerial system (UAS) 4-6 times per year (2019-2022) at three sites in the Great Basin LTAR (Long-Term Agroecosystem Research) site located in Idaho, USA. These sites represented an elevational and climatic gradient from a low-elevation, dry Wyoming big sagebrush (*Artemisia tridentata wyomingensis*) and green rabbitbrush (*Chrysothamnus viscidiflorus*) dominated community, to low sagebrush (*A. arbuscula*) community at mid-elevation, and mountain big sagebrush (*A. tridentata vaseyana*) and snowberry (*Symphoricarpos oreophilus*) dominated community at the highest elevation site. We used spectral data from color and multispectral flights, and structure from motion (SfM) photogrammetry point clouds to assess shrub volume and growth. By flying multiple times per year, we were able to track phenological changes to assist in species classification and measure production differences between years. Finally, we provide management recommendations and lessons learned for using UAS in rangelands.

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The “buzz” on virtual fencing: Livestock behavior in response to aural cues and electronic stimulation

Kendall Hays, Courtney Duchardt, Laura Goodman, Ryan Reuter, Alayna Gerhardt, Federica La Manna Hernandez, Kevin Wagner

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Abstract

Before the introduction of widescale ranching and European settlement in the new world, bison would graze freely across the landscape without manmade barriers like fencing. Today, ranching depends on stable fencing systems to ensure effective grazing management. Fences keep cows from overgrazing a sensitive area or keep them in an area that needs to be grazed. However, traditional fencing systems can be very expensive and require a lot of labor to maintain and move. Further, in some parts of the US, fences can impede large-scale migrations of native ungulates like pronghorn (*Antilocapra americana*). The introduction of virtual fencing systems would help to eliminate some of the problems that come with traditional fencing systems. However, when you lack a physical boundary, it is unclear whether cows will stay within target areas. Virtual fencing uses GPS enabled-collars on cattle to understand their movement and grazing habits, but this technology also functions as a deterrent for crossing over virtual boundaries, using aural cues followed by electric stimulation. In this way, they function much like perimeter collars for dogs. For this study, we will use GPS data from cattle collars as well as information about sound triggers and electrical stimulation to determine 1) how long it takes individual cows to respond to aural cues alone, 2) how much variation there is among individual cows in sensitivity to aural cues and 3) overall effectiveness of aural vs. electrical stimulation. Information on cattle behavior will allow ranchers to identify individuals that are less receptive to virtual fencing, removing these from herds. Further, this research will allow us to understand lags in responsiveness to aural vs. electric cues, and how wide these digital boundaries must be to be effective.

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Critical questions for pre-emergent herbicides in sagebrush steppe: longevity of target and non-target effects on species and ecosystem properties

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Abstract

Selective herbicide application is a common strategy to control exotic invaders that interfere with native plant recovery after wildfire. Whether spraying with pre-emergent or bio-herbicides releases native plants from competition with exotics ("spray-and-release" strategy) and makes communities resistant to reinvasion by exotic annual grasses (e.g., cheatgrass, medusahead), without risks to non-target native plants or secondary invasion, is a major question for land managers of semiarid plant communities. Additionally, how these treatments affect plant-soil feedbacks is important and poorly understood.

We applied chemical herbicides (imazapic, rimsulfuron) and weed-suppressive bacteria (Pseudomonas fluorescens strains MB906 and D7) after fire to three sagebrush-steppe communities that spanned a climate gradient. We measured plant cover prior to burning and for 5 years post-treatment and soil mineral N, potential net N mineralization, and CO2 respiration, in the second year after treatment.

Both chemical herbicides significantly reduced exotic annual grass cover in all communities in the first post-spraying year, but rimsulfuron plots were re-invaded after 1-2 years, while imazapic plots continued to resist re-invasion 5 years post-spraying. Rimsulfuron was more damaging than imazapic to shallow-rooted perennial bunchgrasses (*Poa secunda* and *Poa bulbosa*). Preliminary results showed both chemical herbicides resulted in increased mineral N in proportion to their reductions in total plant cover. Weed-suppressive bacteria treatments had no significant effects on cover of any functional group, but preliminary results showed decreased potential net N mineralization and increased CO_2 respiration two years after their application.

While short-term effects of chemical herbicides were relatively consistent and predictable, longer-term effects were specific to the herbicide and plant community. Herbicide treatments can exacerbate pulses of mineral nutrients, which previous studies have shown can weaken ecosystem resistance to invasion. Restoration strategies that increase the likelihood that desired plants such as native perennials can capture mineralized nutrients after herbicide application will likely be more successful.

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Grassland risk and vulnerability to woody encroachment in the Great Plains

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Abstract

Vulnerability and risk frameworks have emerged as important tools for understanding large-scale threats and developing adaptation strategies. In grasslands, these frameworks can be used to better identify the threat of woody encroachment and structure management plans from pasture to biome scales. Risk is driven by two components: sensitivity and exposure. Sensitivity reflects the rate of transition between grass- and woody-dominated state and is influenced by factors like climate, fire, and grazing. Exposure is driven by seed production and dispersal from woody plants into grassland. Over the last century, the Great Plains grasslands have experienced an increased risk of woody encroachment, largely due to fire exclusion policies and tree planting initiatives, although other factors have also contributed. Past management approaches characterized by the brush management paradigm have been unable to address trends of encroachment at targeted scales, highlighted by unprecedented levels of encroachment in U.S. rangelands, which highlights the overall lack of adaptive capacity to deal with the threat of encroachment. One shortcoming of the brush management paradigm is that treatments often fail to reduce risk, and instead result in perpetual management of brush. Recent research illustrates the importance of management strategies that target both exposure and sensitivity to reduce underlying risks that make grasslands vulnerable to encroachment. In this presentation, we highlight rangeland research behind risk and vulnerability frameworks for better understanding the threat of encroachment and structuring management plans.

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Long-term cheatgrass (*Bromus tectorum* L.) control with indaziflam in sagebrush-grasslands in Sublette County, Wyoming: research synthesis and future directions

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Abstract

Invasive winter annual cheatgrass (*Bromus tectorum* L.) has invaded vast expanses of sagebrush-grassland in western North America, and the fine fuel associated with invasion increases the frequency of wildfire such that native plants struggle to persist. Rangeland managers and scientists have long been aware of this annual grass-fueled "downward spiral", but developing tools with the capacity to effectively manage invasive annual grasses remains critical to preventing further conversion of native rangeland to fire-prone annual grass-dominated plant communities. The herbicide indaziflam (Rejuvra®, Envu), recently labeled for use in grazed areas, provides multi-year annual grass control with minimal harm to established perennials. In September 2016, we established several indaziflam studies in Sublette County, Wyoming to evaluate the long-term effectiveness of this promising new tool and the potential for non-target impacts to native plants. Our studies included large aerial treatment and control plots (approx. 2 ha) established to evaluate the effects of aerial indaziflam treatment (helicopter; 73 g ai ha^{-1} with 47 L ha^{-1} of water carrier), and smaller-scale comparisons of one and two applications (45 months between treatments) of multiple indaziflam application rates (51, 73 and 102 g ai ha^{-1}) and a standard imazapic rate (Plateau®, BASF; 123 g ai ha^{-1}). We will briefly synthesize our research findings, highlighting key insights and focusing on data collected in 2021 and 2022, 57 and 69 months after treatment (MAT), respectively. Data collected in the aerial plots indicated that indaziflam treatment did not impact established native perennials, and in some cases a single indaziflam application reduced cheatgrass cover and density to very low levels at least 57 MAT. Indaziflam can help achieve weed management objectives that are not feasible using other herbicides, and will likely be a powerful tool for land managers tasked with mitigating the impacts of invasive annual grasses in grazed areas.

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Connecting wind erosion estimates to ecological site descriptions for risk assessment using quantitative ecological state keys.

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Abstract

Wind erosion is a critical concern on rangelands in the United States and globally. Along with local land degradation and loss of soil resources, wind erosion has important feedbacks with ecosystem structure and composition and can impact human health and air quality downwind from dust emission sources. Making information about wind erosion accessible to land managers, and providing interpretive tools that support existing workflows, is needed to effectively mainstream wind erosion assessments and action in land use and rangeland management planning. Erosion processes are often difficult to measure in situ, so models are an important tool for understanding the impacts of ecological change on erosion, and vice versa. The Aeolian Erosion Model (AERO) is an aeolian transport and dust emission model developed in part as a decision-support tool for land management. Ecological Site Descriptions (ESDs) are another set of decision-support tools that describe the fundamental ecological dynamics of a site based on soil and plant community characteristics. Here, we demonstrate how the AERO outputs, probabilistic estimates of horizontal sediment flux and dust emission, can be used in multiple ways to assess risk of wind erosion and connect these outputs to ESDs via quantitative ecological state keys. The ecological state keys were created by incorporating quantitative indicators of ecological states and thresholds between states from published ESDs and their associated State-and-Transition Models (STMs). The ecological site keys and AERO were applied to a subset of Bureau of Land Management (BLM) Assessment, Inventory, and Monitoring (AIM) plots in Major Land Resource Area (MLRA) 42. AERO outputs were then assessed at both the ecological site and state levels via the quantitative keys. Our results provide the basis for a risk assessment framework to facilitate management decisions related to potential wind erosion and its effects on ecosystem services.

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Non-Bee Arthropod Site Use During Native Grassland Rehabilitation in the Texas Southern and High Plains

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Abstract

As part of other research projects, it was noted that numerous arthropod species were found in the same habitat as native bees. Additionally, we observed arthropod species on the same vegetation as the native bees, as well as on vegetation that the native bees were not observed on. The objective of this study was to identify the arthropods being captured to form a better understanding of how they may utilize the same habitat as native bees. Pan trap (bee bowls) methodology was used at each site to capture bees and other arthropods. The bee bowls were set out for four hours (10:00 – 14:00) during two time periods during the summer of 2022: 1) early summer (May/June) and 2) mid-summer (July). During these time periods, vegetation inventories were performed to determine the relationship between the vegetative composition and the species captured. Most of the plants present at the sites were volunteer species, (*Berlandiera lyrata, Machaeranthera pinnatifida*, and *Kochia scoparia*), opposed to pollinator species that had been planted. A greater number of arthropod families were captured during the early summer period compared to late summer. At the Pantex site, *Rhaphidophoridae* was the most common family caught, followed by *Cicadellidae* and *Meloidae. Cicadellidae* was the most common family caught at Bamert, followed by *Muscidae*. However, *Cicadellidae* was not captured often at the Gipson site; instead, *Acrididae, Coreidae*, and *Muscidae* were the most common families. Monitoring arthropod diversity can provide another parameter beyond native bee populations that can provide insight into the ecosystem health of the sites and allow better observations of changes in the community during grassland rehabilitation.

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Rangeland remote sensing for climate resilient ranches and rangelands in California

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Abstract

California's 34 million acres of rangelands are vulnerable to climate change and weather extremes. Rangeland managers need timely quantitative data via interpretable outputs across the vast landscapes they manage to improve drought preparedness and climate-smart adaptation strategies. Here, we provide updates from our group's progress on forage production monitoring and improved understanding of production sensitivity to climate change across California's annual grasslands. We developed a locally-calibrated remote sensing algorithm to map daily forage production at 30m. Leveraging the 14 years of forage records derived from fused MODIS and Landsat imagery, we used a machine learning technique was to interpret drivers of spatial variability and to model temporal sensitivity of forage production to changing climate. This big data analysis showed varying sensitivity of forage production across ecoregions to seasonal precipitation and temperature changes. Our findings highlight the importance of locally-calibrated support tools for rangeland management and climate adaptation.

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The impact of long-term stocking rates on soil moisture content and drought resilience

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Abstract

Stocking rate is one tool that producers have to manage impacts on their rangeland. Repeated heavy grazing can negatively impact plant communities resulting in shifts to more undesirable species. This can cascade in unintended consequences of reduced forage production and poor water infiltration which can be magnified under drought conditions. Measuring soil moisture content under different stocking rates allows for a more thorough understanding of how grazing management impacts drought resilience. A long-term grazing study has been conducted at the South Dakota State University Cottonwood Field Station since 1942. The study includes six different pastures as a randomized complete block with three levels of grazing intensity (light, medium, heavy) in two replicate blocks. When the study was initiated, pasture boundaries were situated to uniformly allocate topographic features (hills, draws, ecological sites) across treatments. Those pastures have since been stocked with yearling steers to maintain pasture treatments. The long-term application of these stocking rates has created three distinct plant communities ranging from highly diverse mid-grass dominant (light grazed; western wheatgrass, green needle) to shortgrass dominant (heavy grazed; buffalograss, blue grama). Soil moisture sensors were placed in each pasture at 15, 31, and 61 inch depths; there were 3 replicates per depth. Sensors recorded data during the 2022 grazing season from March through May. Results indicate that soil moisture was lowest in the heavy grazed pasture, while there was no difference between the medium and light grazed pastures. Similarly, peak production in the pastures was approximately 550 lbs/ac (heavy) compared to 1032 and 1305 lbs/ac (medium and light grazed, respectively). Together, these results suggest that helping producers adopt management practices that include a calculated stocking rate appropriate for the growing conditions can minimize negative impacts on forage production and foster drought resilience.

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Effects of Indaziflam Application Timing on Annual Grass Control at Seven Rangeland Sites

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Abstract

Annual grass germination often occurs following sufficient fall precipitation, so widely-used preemergent herbicides need to be applied with adequate time for precipitation-driven incorporation before germination or emergence occurs. Indaziflam has a long soil residual, allowing for increased application opportunities before annual grass emergence. Our objectives were to 1) evaluate the effects of different application timings on winter annual grass control with indaziflam alone and mixed with imazapic or rimsulfuron, and 2) evaluate perennial grass tolerance to the same applications. Different rates and combinations of indaziflam alone and mixed with imazapic and rimsulfuron were applied at three pre-emergent timings at seven sites across Wyoming, Utah, and Colorado. We evaluated May, June, July, and August herbicide application timings (application months varied by site). Dominant annual grass species varied among sites: at two sites it was ventenata (Ventenata dubia), cheatgrass (Bromus tectorum) at two sites, and Japanese brome (Bromus japonicas) at three sites, with one of those three having a sub-component of cheatgrass. We recorded canopy cover of target annual grass species and non-target species one and two years after application along with control ratings two years after application. We analyzed data using ANOVA with site, herbicide treatment, and month of application as factors. In general, herbicide treatments reduced target annual grass cover one and two YAT, but magnitude of reduction varied among sites and target species (i.e. ventenata vs. bromes). Indaziflam plus imazapic or rimsulfuron more consistently reduced annual brome cover one YAT than did indaziflam alone. Ventenata cover was greatly reduced by all herbicide treatments one and two YAT. Perennial grass cover increases were less consistent with high variability among sites and treatments. Our results suggest that annual grass control with indaziflam and tank-mix partners is relatively robust across application timings and that susceptibility differs across sites among target species.

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Precision Supplementation Effects on Heifer Development and Reproduction

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Abstract

Improving individual animal efficiency is important for livestock producers to run a financially sustainable operation. Precision livestock management technologies can help reduce feed waste, optimize individual animal intake, and enhance proper heifer development. The objective of our study was to compare differences in yearling heifer growth and reproductive performance between conventional and precision delivered supplementation on beef heifers grazing dormant winter range. The study was conducted at the South Dakota State University Cottonwood Field Station (Philip, SD). Spring born Angus heifer calves (n=60) were utilized for the project. Heifers [initial body weight (BW) = 237.6 ± 15.5 kg] were allocated to one of two treatment groups, control or precision, and grazed dormant native range from November 2021 to May 2022. Both treatment groups were supplemented with 2.27 kg/hd/d of pelleted dried distiller's grains with solubles (DDGS). Supplement was delivered to the control group in a traditional bunk fed method and the precision group supplement was offered with a Super Smartfeed ProducerTM (C-Lock Inc.). Individual daily BW was measured using SmartScalesTM (C-Lock Inc.) and was used to calculate daily rate of gain. Heifers were bred in June 2022 using estrous synchronization with fixed time artificial insemination. Average daily gain was evaluated between control and precision treatments using ANOVA. Logistic regression was performed to compare pregnancy rates. Results indicate a difference ($P < 0.05$) in ADG between control and precision treatments with mean ADG of 0.878 (± 0.019) and 0.798 kg/d (± 0.016), respectively. Pregnancy rate did not differ ($P = 0.142$) between control (83.3%) and precision (66.7%) treatments. Further, the control group utilized 2,547 kg more feed compared to the precision group. This study suggests that precision supplementation can decrease heifer development costs by reducing intake variation and supplement overconsumption without negatively influencing heifer performance.

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Improving Riparian Ecosystem Health with Virtual Fencing

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Abstract

Riparian areas play a crucial role in grazinglands and are sensitive to improper grazing management. Improper livestock management practices can negatively influence soil and water quality, vegetation diversity, and wildlife habitat. Physical fencing often protects riparian ecosystems, although that has several drawbacks. Constructing or repairing fencing may not be cost-effective, because fencing supplies and labor costs are at an all-time high. Additionally, physical fences do not offer the flexibility of changing grazing patterns that may be beneficial when grazing near riparian areas. Virtual fencing (VF) allows new management capabilities that can positively influence riparian areas. Virtual fencing uses GPS-enabled collars that provide real-time data and control on an individual animal basis. Virtual fencing technology allows producers to identify sensitive areas within their grazinglands and exclude cattle using initial auditory stimulus, followed by an electrical stimuli. This technology can replace or complement physical fence, moderating some of the limitations of physical fence. However, many producers are unaware of VF's potential. Therefore, the objective of this study was to introduce Oklahoma producers to VF technology and incorporate VF into their grazing systems. We have implemented a VF system and illustrated that it is capable of achieving a 99% reduction in cattle use of a preferred area. Further, we have implemented VF on three additional ranches and plan to document changes in cattle use, vegetation, and water quality in riparian areas over the next three years.

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Invasive annual grasses and fire in the Great Basin: New insights from remote sensing

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Abstract

Rapidly expanding invasive annual grasses pose an urgent threat to sagebrush ecosystems of western North America where they displace keystone shrubs, alter natural fire regimes, and fuel catastrophic wildfires. The accelerating loss and degradation of sagebrush ecosystems resulting from positive feedbacks between invasive annual grasses and fire is increasingly seen as an existential threat to sagebrush obligate wildlife such as sage-grouse, yet halting this ecosystem transformation has vexed managers for decades. Using dynamic, remotely-sensed rangeland vegetation data, we track the 8-fold expansion of invasive annual grass dominance over the past 3 decades in the Great Basin, highlighting the recent movement into higher elevations and north-facing aspects previously considered unlikely to experience such transitions. We then use remote sensing-derived wildfire perimeter and burn severity datasets to explore the role of fire in transitions to annual grass dominance. Although annual grasses and wildfire are so tightly associated that one is rarely mentioned without the other, our findings reveal widespread transformation of sagebrush ecosystems by invasive annual grasses in the absence of fire. These findings are discussed in the context of strategic management; we argue a pivot from primarily reactive management (e.g., fire suppression and post-fire restoration in heavily-infested areas) to proactive management (e.g., enhancing resistance and managing propagule pressure in minimally-invaded areas) is urgently needed to slow or reverse the loss of Great Basin sagebrush ecosystems.

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Effects of seed coatings on emergence and survival of winterfat

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Abstract

Winterfat (Krascheninnikovia lanata) is a protein-rich subshrub native to western North America that has been displaced from much of its native range. Success in restoring this species to the landscape has been limited due to seed handling difficulties and low seedling establishment. Seed coating technologies may present a solution to both of these problems. Winterfat seeds are enclosed in fruits that are densely covered in hairs which impede flow through equipment like rangeland drills and broadcasters. Consequently, the species is often excluded from restoration seed mixes. Applying coating material to fruits compresses hairs down and creates a flowable product, thus improving seed handling. Additionally, additives can be applied to coatings to mitigate specific environmental stressors that prevent seedling establishment. We examined the use of fungicide coatings to reduce seedling mortality from pathogen attack, and hydrophobic coatings to delay germination until spring and reduce seedling exposure to lethal winter conditions. We compared emergence of fruits coated with calcium-carbonate (blank coating), fungicide, hydrophobic material, and combination coatings to control fruits. Studies were planted in the fall of 2021 at four field sites in the Great Basin Region of the United States and emergence was counted in the spring of 2022. We found that emergence was greatest for fruits with a hydrophobic coating ($p < 0.01$), and all other treatments were statistically similar to the control. This finding suggests that hydrophobic seed coatings may improve direct seeding success of winterfat by improving seed handling and delaying germination until spring, reducing exposure to harsh winter conditions.

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Developing monitoring protocols for culturally important forbs in dry forest and rangeland ecosystems of the interior Pacific Northwest

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Abstract

Many forb species of the grassland, shrubland and dry forest ecosystems of the interior Pacific Northwest are important to the health, diet, and culture of Indigenous people of the region. Plateau Tribes depend on forbs such as bitterroot (*Lewisia rediviva*), biscuitroot (*Lomatium cous*), desert parsley (*Lomatium* spp.), wild onions (*Allium* spp.), and camas (*Camassia quamash*) for subsistence and ceremonial purposes. Corms, roots, tubers, bulbs, and new leaf growth ('celery') from over 100 species are seasonably harvested and consumed. However, information on the status, trends, and health of forb populations is lacking and little is known about how invasive species, changing fire regimes, livestock grazing, or land management actions (fuels reduction, stand thinning, prescribed fire etc.) affect forb abundance. We developed a monitoring protocol to address this knowledge gap for the Blue Mountains and Columbia Plateau eco-regions of northeast Oregon. Here, we describe the protocol and share results from the first year of sampling. A collaborative group including tribal, university, agency, and non-governmental organization partners developed the protocols. Protocols utilize permanent plots to measure and track density and frequency of 17 culturally important species and record important site characteristics. Plots are established in areas of concern or interest as identified by tribal partners and land managers, as well as at sites with planned management actions. Plots are sampled prior to treatment which provides pre-treatment data and the ability to monitor forb responses following treatments. Over 70 plots were established in 2022, and this effort is expanding to include additional tribal partners and locations moving forward. Data from this monitoring program will provide valuable information to land managers and improve our understanding how management decisions impact the availability, abundance, and status of culturally significant species.

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Dynamic spatial modeling of common raven densities and a decision support tool to manage predation of greater sage-grouse nests

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Abstract

Anthropogenic resource subsidization across western ecosystems has contributed to widespread increases in generalist avian predators, including common ravens (*Corvus corax*; hereafter, raven). Ravens are adept nest predators and can negatively impact multiple species of conservation concern. Predation effects from ravens are especially concerning for greater sage-grouse (*Centrocercus urophasianus*), which have experienced prolonged population decline. Our objectives were to quantify spatiotemporal patterns in raven density, evaluate sage-grouse nest success concurrent with fluctuating raven densities, and demonstrate hierarchical distance sampling models relating raven density to sage-grouse nest success while accounting for other environmental influences. We combined raven point count surveys with data from more than 900 sage-grouse nests between 2009–2019 within the Great Basin, USA.

We modeled variation in raven density using hierarchical distance sampling with environmental covariates on detection and abundance, while sage-grouse nest survival was estimated concurrently using a hierarchical frailty model with covariates influencing failure risk. We related raven densities directly to sage-grouse nest survival using a two-stage approach within a Bayesian modeling environment. We simulated sage-grouse nest survival under current and reduced raven densities, where the difference indicated potential impact on nesting productivity. Raven density commonly exceeded >0.5 ravens per square km and increased at low relative elevations with prevalent anthropogenic development and/or agriculture. Reduced sage-grouse nest survival was strongly associated with raven density and also varied with topographic ruggedness, shrub cover, and burned areas. Results inform spatially-explicit conservation planning, while our modeling framework is compatible with modern population modeling. Information is preliminary and provided for best timely science.

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Spatial patterns and controls on wind erosion in the Great Basin

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Abstract

The Great Basin, containing a large portion of the managed rangelands of the western United States, is experiencing disturbances due to wildfire and cheatgrass (Bromus tectorum) invasion that potentially accelerate wind erosion and plant community change. While these disturbances have been linked to increased wind erosion and dust emissions at local scales, no comprehensive study has investigated interactions between wildfire and invasive cheatgrass at the regional scale across the Great Basin. This study used a wind erosion and dust emission model (AERO) parameterized for rangelands to leverage standard monitoring datasets (e.g., BLM AIM) to: 1) characterize the magnitude of horizontal sediment flux — a measure of aeolian sediment transport (Q, g m-1 day-1) — at rangeland monitoring plots to identify eroding dust source regions, 2) describe the relationships between weather, soil, vegetation cover, geography, and disturbance and Q, 3) quantify effects of wildfire and invasive cheatgrass cover and structure on Q, and 4) identify thresholds in ground cover indicators used as inputs to AERO that can be used as benchmarks for wind erosion assessment across Major Land Resource Areas (MLRAs) comprising Great Basin. We found the Fallon-Lovelock Area (MLRA 27) had the highest and Snake River Plains (MLRA 11) the lowest average wind erosion indicated by modelled Q. Plant cover and precipitation were negatively related and measures of bare ground and canopy gap size distribution were positively related to Q. The probability of Q occurring was consistently high with invasive plant species cover but decreased with the number of fires associated with monitoring plots sampled in the Great Basin. Thresholds in indicators of vegetation cover varied with the level of Q within and between MLRAs, suggesting that when bare ground is greater than ~20 %, Great Basin rangelands are at risk of accelerated wind erosion.

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Intact Habitat for Greater Sage-Grouse Includes Biological Soil Crusts

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Abstract

Biological soil crusts (biocrusts) are a common component of plant communities in shrub-steppe ecosystems. The sagebrush steppe of the Great Basin is unique in its known disturbance history. Previous work in the region has linked the loss of biocrusts to disturbance and to increases in cheatgrass, Bromus tectorum. Cheatgrass is responsible for altering fire regimes, leading to increased loss of sagebrush that threatens the persistence of sagebrush obligate species such as the greater sage-grouse (Centrocercus urophasianus). We used data collected by the Assessment, Inventory and Monitoring (AIM) program of the Bureau of Land Management, specifically the Landscape Monitoring Framework, in combination with a long-term dataset of sage-grouse nest locations and fates collected across the region. We used Bayesian generalized mixed models to examine hypothesized relationships between abiotic conditions represented by the Resistance and Resilience (R&R) classification, disturbance induced losses of biocrusts, subsequent increases in cheatgrass and alterations to nesting patterns of sage-grouse. Preliminary results indicate that in the presence of fire, cover of lichens was increasingly associated with reduced cover of cheatgrass. In the presence of grazing, cover of perennial grasses was increasingly associated with reduced cover of cheatgrass. Nest selection had a greater probability of occurring on sites with greater cover of sagebrush, especially on moderate R&R sites, and greater cover of perennial grasses on low R&R sites. Nest survival was negatively influenced by cheatgrass cover and positively influenced by perennial grass cover at coarse spatial scales. Cover of lichens and mosses were negatively associated with cover of cheatgrass, and cover of mosses was positively associated with cover of perennial grasses. Our preliminary results suggest that the presence of biocrusts has cascading positive effects on breeding life stages of greater sage-grouse. These findings are preliminary, are provided for timely science communication, and are subject to change.

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Great Plains fire cultures: Opportunities to align science, policy, and management

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Abstract

The grasslands of the Great Plains provide a myriad of ecosystem services under threat from woodland encroachment. To manage this "green glacier" of woody plant species (e.g. Eastern Red Cedar), prescribed burning is often recommended for its cost efficiency and ability to impact all stages of woody invasion. However, the rate of prescribed burning is not keeping pace with the rate of woody plant expansion. To scale up fire management to larger spatial scales, particularly in areas dominated by private lands with no central governing body, significant landowner coordination and agency support is required. When agency policy, scientific guidance, and private lands management practices significantly differ, environmental challenges arise. Through a literature review and modified Delphi methodology, we identify and outline typologies of Great Plains fire cultures to understand the intersection of private lands management, scientific guidance, and supporting agency policy. Specifically, we (1) catalog the different private lands fire management cultures in Great Plains rangelands, (2) characterize the disparate supporting entities associated with Great Plains rangelands and their associated management policies regarding fire use and/or suppression, and (3) assess the degree of mismatch between the latest scientific knowledge/guidance, private lands management, and supporting agency policy. We conclude with policy change recommendations that would better align with fire community needs and recent scientific guidance.

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A review of assembly mechanisms underlying secondary plant invasion

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Abstract

Plant invasions are accelerating, and invasive control efforts are common in land management to prevent damage to critical ecosystem services and biodiversity. However, secondary plant invaders often recolonize open space following species removal targeted for management, or inadvertently culled by grazing pressure. Secondary invaders can sometimes be more noxious, and in certain areas they can more negatively affect key ecosystem services compared to the primary invaders they displaced. Currently it is hard to preemptively determine the identity of the secondary invader because they are not always a central component of experimental designs and often considered a posteriori; but greater understanding could be useful generating adaptive management. Past reviews focused on how different management practices may result in different levels of secondary invasion, but plant assembly theories and mechanisms has not yet been integrated to understand patterns across these experiments. Understanding assembly mechanisms underlying secondary invasion can also allow land managers to co-opt these mechanisms to instead facilitate the recruitment of desirable species. To better understand the utility of assembly theories in predicting the identity of secondary invaders we conducted a review focused on experimental work with targeted removal treatments across a variety of habitats and regions. We reviewed key citations and numerous experimental studies that were found using a combination of key search terms: "invasive plant" OR "non-native plant" OR "nonnative plant" OR "exotic plant" OR "weed" AND "control" OR "remov*" AND "secondary invasion". We demonstrate that key assembly theories such as niche-based assembly, fitness-based assembly, neutral assembly, and stabilizing selection can inform secondary invader identity in different environmental contexts. We conclude by providing recommendations on how these assembly mechanisms could be repurposed to promote the recruitment of desirable species.

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Effects of grazing exclusion following indaziflam treatment on rangelands of northeast Wyoming.

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Abstract

Ventenata (*Ventenata dubia*) is an annual grass native to Mediterranean Europe that has invaded Western North America. Ventenata has low forage value and may alter the natural fire regime of rangelands, promoting wildlife habitat loss. Ventenata is expanding its range eastward from the intermountain west toward the great plains. Ventenata was identified in northeast Wyoming in 2016 and is expected to be an extremely competitive weed in the Great Plains ecoregion. Indaziflam is a cellulose biosynthesis inhibitor herbicide labeled for control of annual grasses that shows long-term soil activity. Management recommendations from some government agencies include grazing deferment for one to multiple growing seasons following indaziflam application to promote regeneration of perennial plant communities. We focused on understanding the effects of grazing exclusion following indaziflam application on perennial plant communities across two ecological sites at four locations in northeast Wyoming. Sites were treated with 123 g ai ha-1 indaziflam applied in 18.9 L ha-1 from a helicopter in 2019. At each site, we excluded grazing using electric fence during the growing season and allowed ambient grazing in an adjacent, paired plot. We collected plant community data collected via ocular cover estimates, line point intercept, perennial grass gap measurements from 2019-2022 and analyzed vegetation data using a 3-way repeated measures model with grazing, ecological site, and year as factors of interest. Preliminary results indicate that grazing exclusion had no effect on multiple vegetation attributes, suggesting that grazing exclusion may not be necessary to meet vegetation goals.

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A Comparison of Ground and Remote Sensing Methods for Estimating Sagebrush (*Artemisia spp.*) Cover

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Abstract

Sagebrush (*Artemisia spp.*) is an integral component of western rangelands and wildlife habitat. Due to prior land management objectives, altered fire regimes, and conifer encroachment, sagebrush communities have been declining in recent years. Many sagebrush obligate species are negatively impacted by this decline and require effective habitat monitoring which is often informed by sagebrush cover estimates. As such, it is critical to take consistent and accurate sagebrush measurements to inform land management decisions. The purpose of this study is to compare the advantages and limitations of various shrub cover methods that are currently used in land management, including emerging remote sensing methods. We surveyed 21 plots throughout Utah in stands of big sagebrush (*Artemisia tridentata*) using ground and remote sensing methods to estimate shrub cover. We measured sagebrush cover using drone imagery, photopoints, line-point intercept, line intercept, and belt transects. Based on results from pairwise t-tests comparing ground measurements, there was a significant difference ($p \leq 0.05$) between the estimates of line intercept and belt transects. The mean belt transect estimate (21.5%) of sagebrush cover was higher than that of line-point intercept (18.9%) or line-intercept (18.3%). There was no significant difference ($p > 0.05$) between the estimates derived from line-point intercept and line intercept or between line-point intercept and belt transects. We will estimate sagebrush cover from drone and satellite imagery using object-based image analysis (OBIA) in eCognition and ArcGIS Pro. Additionally, photopoints will be distributed to land managers to assess the accuracy of sagebrush cover estimates made visually. The results of these estimates will be compared with ground measurements using pairwise t-tests. The intended application of the research is to inform selection of shrub cover estimation methods in land management based on given monitoring objectives.

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Soil carbon balance under adaptive multi-paddock and conventional grazing in the Texas Southern Plains.

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Abstract

Recent average atmospheric CO2 concentrations have exceeded the past millennia's maximum by 137.5%, with an annual rate of increase one-hundred times faster due to anthropogenic activities as compared to natural processes occurring in the last ice age. These levels are unequivocally contributing to climate change and ocean acidification. Forestland and cropland practices that accelerate carbon sequestration are being promoted and implemented to reduce greenhouse gas levels. However, despite their extensive coverage and provisions of critical ecosystem services, relatively little attention has been paid to the role of grasslands as carbon sinks. Improved grazing management is needed to ensure global resiliency and sustainability. A potential best management practice known as Adaptive Multi-Paddock (AMP) grazing mimics the effects of historic large ungulate herbivory on the evolution of vast grasslands. Some research has shown that AMP grazing can substantially improve ecosystem services and economic returns when compared to traditional season-long continuous grazing (CG) and may serve as a mitigation tool for rangeland degradation and climate change. However, there are methodological gaps and discrepancies in the AMP grazing literature, and inconsistencies in CO2 sequestration efficacy of AMP grazing. The purpose of this project is to compare two climatically and edaphically similar AMP and CG cow-calf ranch pairs in two distinctive ecoregions of Texas. The annual C budgets of the pairs will be compared for key C inputs of biomass production, fine root mortality, and fecal matter and outputs of total soil respiration and 13C isotope Keeling Plots to differentiate autotrophic and heterotrophic respiration. Additionally, various climatic conditions will be monitored to determine if weather patterns also show a significant relationship with soil respiration. This data will help identify grazing management practices that result in greater CO2 sequestration and provide ranchers with possible solutions to increase resiliency and mitigate future climate variability and uncertainty.

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Understanding practitioner weed management practices and needs in Arizona and Utah

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Abstract

Climate and land use change are resulting in rapid declines in the health and productivity of rangelands. To address these rapid transformations, targeted and effective management actions must be developed and implemented across broad regions. However, effective management can be hampered by disconnects between academic research and land management practices, hindering the implementation of effective management. This is evidenced through the disconnect that can exist between research programs and weed management practitioners. Research relevant to the ecological and evolutionary processes of plant invasions is not always made available or directly relevant to weed management practitioner needs. To address this “research-implementation gap”, we surveyed weed management professionals in a variety of fields throughout Arizona and Utah. The survey asked participants to list problematic weed species and expand on their current weed management practices. We also asked practitioners to indicate the effectiveness of those practices and implementation gaps related to less-used practices. Importantly, we asked respondents to indicate their sources of weed management information. We collected responses from 134 survey participants across Arizona and Utah in a variety of fields, including Extension agents, County weed board members, private weed consultants, and researchers. We found a diverse list of species that practitioners are targeting and ways in which they are targeting them. Taken together, the dataset provides important information about weed management practices practitioners are using, gives researchers insight into the obstacles faced by practitioners and research gaps that can be filled, and gives researchers the means to bridge the research-implementation gap by providing information to practitioners in places they are routinely accessing information.

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Evaluating integrated control practices for cheatgrass at high elevation sagebrush sites

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Abstract

Herbicide, grazing, seeding and combinations of these are the most common methods to control cheatgrass. Fall emergence of cheatgrass is commonly controlled with fall application of Plateau (a.i. imazapic). Grazing cheatgrass in fall or spring can provide livestock forage and reduce biomass. Heavier use or more targeted grazing during these times in combination with other approaches may be more effective at reducing cheatgrass abundance and seed production rather than just providing a forage opportunity, but results can be variable. The other commonly used approach is seeding following herbicide application, which can also have variable effectiveness. We assessed the efficacy of herbicide application, targeted grazing, and seeding on cheatgrass abundance and native species response, using a factorial design at eleven sites in the Centennial Valley, MT. Herbicide (imazapic at 6 oz/acre) was applied fall 2020. Targeted (0.4 AUM/ac) and simulated grazing, and seeding, was performed in fall 2021. Herbicide application reduced the abundance of cheatgrass in the first season. In the second season the herbicide only treatment still had lower cheatgrass abundance but the sprayed and target grazed treatment had higher abundance; other treatments did not differ from the control. Native grass abundance increased in integrated herbicide with targeted or simulated grazing treatments, but not herbicide, targeted or simulated grazing alone. Seeding did not alter abundance. These integrated management results are encouraging, and sites will be monitored in future years.

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Integrated Rangeland Fire Management Strategy Actionable Science Plan Completion Assessment: A Scorecard Approach

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Abstract

The Integrated Rangeland Fire Management Actionable Science Plan represented a significant, co-produced effort to identify Priority Science Needs for coordinated adaptive management of sagebrush ecosystems. A quantifiable assessment for accomplishing these Needs since the Plan's release in 2016 can help evaluate overall success, flag unresolved knowledge gaps, and prioritize new directions. We describe preliminary results from a scorecard-based assessment of Plan progress towards addressing multiple Needs identified under 5 Topics listed in the Plan: Fire, Invasives, Restoration, Sagebrush and Sage-Grouse, and Climate and Weather. We systematically searched peer-reviewed literature published between January 1, 2015 and December 31, 2020 to identify how well Next Steps for each Need were either fully addressed, partially addressed, or remained outstanding. Searches resulted in 1150 science products that at least partially addressed a particular Need across all Topics, with most products addressing Restoration (n = 371) and Sagebrush and Sage-Grouse (n = 333) and fewest products addressing Climate and Weather (n = 92). Example Needs by Topic most fully addressed included elucidating relationships between fire, sagebrush, and sage-grouse (Fire); identifying natural and anthropogenic factors influencing the distribution, spread, and control of invasives plants (Invasives); methods and factors influencing short- and long-term seeding success (Restoration); biome-wide mapping of vegetation, and spatially explicit models of sage-grouse habitat suitability (Sagebrush and Sage-Grouse); and identifying complex climatic relationships influencing restoration and seeding success (Climate). Example outstanding Needs included identifying factors driving fuel break effectiveness (Fire); using livestock grazing to manage invasive plants (Invasives), developing methods for more rapid recovery of sagebrush and native herbaceous plants post-fire (Restoration); identifying impacts of livestock and feral horses on sage-grouse (Sagebrush and Sage-Grouse); and identifying native plant species and seed mixes most resilient to a changing climate. This scorecard assessment aims to assist with updating the Plan and related science strategies.

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Dietary Preference Nature or Nurture?

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Abstract

We hypothesized that differences in propensity to consume juniper between lines of goats divergently selected for high or low percentage juniper in their diet would result from physiological differences (nature) in the way they coped with plant secondary compounds. To test this hypothesis does from both selection lines were kept on either juniper free rangelands (JFR) or juniper infested rangelands (JIR) from the end of the breeding season until their offspring were weaned. If the difference in percentage juniper in the diet between the selection lines was not affected by rearing environment it would indicate that diet selection was primarily a result of changes in the goats' physiological ability to ameliorate the effect of chemical defenses against herbivory in the juniper plants. However, if kids from the two selection lines raised on JFR consumed similar percentages of juniper in their diet when grazing JIR it would indicate that diet selection was primarily learned. Finally, if kids raised on JFR from the high line had a higher percentage juniper in their diet than kids from the low line but the difference was smaller than for kids raised on the JIF it would indicate the difference was a combination of physiological and learned behavior. Results showed that percentage juniper in the diet of goats selected for low juniper consumption regardless of their rearing environment were lower than goats selected for high juniper consumption ($P < 0.001$). Kids selected for high juniper consumption consumed 2.5 times as much juniper as kids selected for low juniper consumption. However, the selection line by rearing environment was significant ()p = 0-.001) and indicated that kids selected for high juniper consumption and raised on JFR consumed less juniper than kid raised on JIR. This indicates that both environment and genetics determine the consumption of chemically defended plants.

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Vegetative Fuel Break Establishment and Effectiveness in the Columbia Plateau

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Abstract

Across the west wildfires are increasing and more innovative tools are needed to create better defensible space across rangelands. Vegetative fuel breaks or greenstrips are fuel breaks that are intentionally planted with perennial vegetation with increased fuel moisture and reduced volatility. These fuel breaks, often with forage kochia, have been used in the Great Basin to slow wildfire spread and give firefighters a strategic area where they can safely suppress the wildfire. Vegetative fuel breaks are not as common in the Columbia Plateau in North Central Oregon. Forage kochia (*Bassia prostrata*), blue flax (*Linum lewisii*), and yarrow (*Achillea millefolium*) were examined as possible options for creating vegetative fuel breaks in North Central Oregon. We tested the ease of establishment by direct and broadcast seeding. In addition we did small burn tests to determine the time to ignition, duration of combustion, and flame temperature for these different species. The fuel moisture for these species and surrounding vegetation was recorded throughout the fire season in 2023 (June through September). Establishment was difficult by both methods (due to drought and weed pressure), but all three species exhibited significantly higher resistance to burning in terms of time to ignition compared to cheatgrass (*Bromus tectorum*). We also found that Curlycup gumweed (*Grindelia squarrosa*) in the surrounding landscape had significantly higher resistance to burning. However, blue flax (*Linum lewisii*) did exhibit surprisingly high flame temperatures and long duration of combustion once the seeds were mature. Fuel moistures were also significantly higher for the three species tested compared to cheatgrass (*Bromus tectorum*) throughout the fire season with differences most pronounced at the end of the fire season. If establishment barriers can be overcome both Forage kochia (*Bassia prostrata*) and yarrow (*Achillea millefolium*) should be considered for use in vegetative fuel breaks in this region.

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Common ravens disrupt greater sage-grouse lekking behavior in the Great Basin

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Abstract

Expansion of human enterprise has contributed to increased abundance and distribution of common ravens (*Corvus corax*, raven) across sagebrush ecosystems within western North America. Ravens are highly effective nest predators of greater sage-grouse (*Centrocercus urophasianus*, sage-grouse), a species of high conservation concern. Sage-grouse population trends are estimated using count survey data of males attending traditional breeding grounds, known as leks. We sought to investigate associations of ravens to sage-grouse lek sites and document interactions between sage-grouse and ravens, as well as other animals observed around leks. First, we used extensive raven point counts and sage-grouse lek observation data collected across Nevada and California from 2009 – 2019 to evaluate spatial associations between sage-grouse leks and ravens while accounting for other environmental covariates. We found that ravens were more likely to be observed closer to lek sites, especially as leks increased in size. Second, we used a subset of the lek dataset from 2006 – 2019 to describe behavioral changes of male sage-grouse in the presence of ravens and other predators. Our analysis indicated that ravens are attracted to lek sites and were associated with disrupting sage-grouse lekking behaviors by causing sage-grouse to cease displaying or flush from the lek. These results suggest that adult and yearling sage-grouse perceive ravens as a reason to alter breeding activity and thus ravens may adversely influence sage-grouse reproduction during the lekking stage. Additionally, standardized techniques to count sage-grouse on leks for population trend analyses could be biased low if raven presence during surveys is not accounted for. Findings are preliminary and provided for timely best science.

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Cheatgrass may be replacing medusahead in an annual grass monoculture in SE Oregon

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Abstract

Throughout the Northern Great Basin and Pacific Northwest, the invasive annual grasses medusahead (*Taeniatherum caput-medusae*) and ventenata (*Ventenata dubia*) have become the primary species of concern on rangelands. As winter annual grasses they are competitive with cheatgrass (*Bromus tectorum*) in sites that have been disturbed by wildfire, experienced drought, recreation, and past mismanagement of grazing. In recent years there has been growing concern that medusahead and ventenata may replace cheatgrass, leading to decreased forage value as both are regarded as extremely poor and unpalatable forages for wildlife and livestock. Little is known about the interactions between these annual grasses and how factors such as climate (i.e., timing of precipitation and ambient temperature) and grazing practices may benefit one species over the others. From 2018-2022 species composition data was collected on a BLM allotment in Southeast Oregon. Historically, the allotment was a Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*) site but due to multiple fire events, the current conditions are a near monoculture of invasive annual grasses. Between 2018 and 2022 the total abundance of invasive annual grasses remained consistent, with total cover greater than 60% in all five years. However, during that time the relative cover of medusahead has decreased from 82% to 67% ($p<0.001$). Additionally, cheatgrass has increased from 11% to 27% relative cover ($p<0.001$). The prevalence of field brome (*Bromus arvensis*), another annual grass, has also increased from 3% to 6% relative cover ($p>0.001$). These changes were observed regardless of grazing management strategies. We will perform a covariate analysis using precipitation and temperature data for the growing season (October-June) to better understand what climatic factors may be contributing to this change in species composition.

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Influence of large domestic ungulates on greater sage-grouse population patterns and breeding habitats

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Abstract

Greater sage-grouse (Centrocercus urophasianus) is a sagebrush obligate bird species found throughout western North America. Over the past 60 years, sage-grouse populations have been declining due in part to anthropogenic and natural disturbances. In addition to greater sage-grouse, free-roaming horses occupy sagebrush dominated landscapes where they influence rangeland health and natural resource sustainability. Free-roaming horse populations have exponentially increased since the passage of the Wild Free-Roaming Horses and Burros Act of 1971 which protects horses on public lands ensuring readily available access rangeland resources. The purpose of this study is to characterize the influence of free-roaming horses and cattle on greater sage-grouse abundance and habitat quality by 1) quantifying sage-grouse lek attendance in horse use and non-use areas and 2) determining the potential influence of grazing by horses and cattle on sage-grouse late brood-rearing habitat. Using lek count data, vegetation sampling, and soil compaction, we were able to assess differences between horse use and non-use areas. Our data found that sage-grouse lek counts declined at lek sites over time and cheatgrass frequency increased in brood rearing areas where horses and cows are present. These data can be used to predict the potential influence of horses and cattle on sage-grouse populations and provide managers with information on potential impacts that stem from large ungulate grazing.

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Linking on-ground plant functional group biomass production to remote sensing in the semi-arid grasslands of the Nebraska Sandhills

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Abstract

Plant biomass production on native rangelands has been impacted by intra- and inter-annual precipitation and temperature variability. The altered plant biomass production can affect adaptive grazing management decisions designed to align seasonally variable forage supply to meet livestock grazing demands among regions. Land managers and producers require timely and effective technical supports to monitor and forecast plant production on rangelands with diverse mixtures of cool- and warm-season species that improve the decision-making process. Remote sensing from the air- and space-borne platforms is being increasingly used because of its advantages of non-destructive observations and simultaneous, repeat coverage of an area. Our study investigated the potential of satellite remote sensing derived Normalized Difference Vegetation Index (NDVI) in assessing the seasonal and annual variabilities of total biomass and the biomass of individual plant functional group under a changing precipitation and temperature pattern in Sandhills region from 2007 to 2021. Our results indicated the proportion of cool-season species biomass in total biomass was increasing, and the proportion of warm-season species biomass was decreasing from 2007 to 2021. The performance of satellite remote sensing in assessing plant biomass variability may direct timely adjustments in grazing management through early warning from monitoring perspective. The study will improve our understanding of tradeoffs between livestock demands and forage supply for rangeland grazing management. In addition, we briefly introduce an on-going study exploring the usage of biomass estimation from unmanned aerial vehicles (UAVs) remote sensing for planning/adjusting schedule of rotational grazing in 2022, which may provide knowledge to support an objective and timely decision-making process for implementation of adaptive rotational grazing. Our study is expected to broaden discussions in the topic of implementation and development of successful integrative adaptive grazing management strategies with assistance of remote sensing, in the face of climate change and anthropogenic management.

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Controlling invasive species and mitigating wildfire risk on Idaho rangelands using targeted grazing by sheep

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Abstract

Cheatgrass (*Bromus tectorum*) invasion increases wildfire risk and negatively impacts sagebrush ecosystems and rangeland-based agricultural production. In sagebrush ecosystems, diverse native plant communities tend to be more resistant to invasion and resilient to disturbances, like wildfire. Grazing has been suggested as a tool to combat cheatgrass and thus promote more resilient vegetation communities. However, most cheatgrass targeted grazing research has been done with cattle, and studies with sheep remain sparse. Here, we introduce a new, transdisciplinary project that aims to answer the question of how sheep can be used to reduce cheatgrass and wildfire risk, while also examining the economic costs and benefits of this practice. In the summer of 2022, our team of researchers, land managers, and sheep producers established a sheep targeted grazing experiment at a management-relevant scale on the Sawtooth National Forest, Idaho. Our grazing treatments will compare dormant-season grazing in spring and fall, when cheatgrass is growing but most perennial species are not, to "traditional" summer grazing. Treatment areas are nested within two allotments grazed by 800-1200 ewes and their lambs. Despite the treatment plots' relatively high elevation (> 2100 m), our baseline measurements indicate that, on average, cheatgrass comprises over 70% of the vegetation cover. Starting from this baseline, we will assess grazing treatment effects on the composition of aboveground vegetation and fuel loads. We will also examine soil processes, and particularly nitrogen availability, to enhance understanding of the ecological mechanisms underpinning our results. Fire behavior models and economic models will estimate the financial and societal costs and benefits of adopting sheep targeted grazing practices to manage cheatgrass invasion and wildfire risk. Finally, our outreach to diverse audiences will build knowledge and shared understanding of the potential for using sheep as a management tool to tackle pressing environmental challenges on western rangelands.

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Post Wildfire Annual Weed Control with Gibberellic Acid

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Abstract

Following wildfires annual weed control can be challenging in most rangelands. Additional tools are needed to make herbicides more effective. The purpose of this study was to determine if the addition of gibberellic acid (RyzUp Smartgrass at 1.00 oz/A) would result in early and uniform germination of cheatgrass and broadleaves that would be more readily controlled by an application of flumioxazin and pyroxasulfone (Fierce @ 9 oz/A) and sulfosulfuron (Outrider @ 1.33 oz/A). In addition, the use of glyphosate (RT3 at 11 oz/A) was tested alone. RyzUp Smartgrass is a plant growth regulator spray formulation containing gibberellic acid (GA3). GA3 is naturally occurring plant hormone that can increase germination in the seed bank. Trial was set up in two different rangeland pastures following a summer wildfire in North Central Oregon. Four plot replicates with 7 treatments were used in a randomized complete block design. Cover was recorded during a fall and spring check following herbicide application in October 2021. The final results and statistical analysis from this study are still being examined at this time, but overall flumioxazin and pyroxasulfone with the use of GA3 provided the best level of control, followed by flumioxazin and pyroxasulfone alone, sulfosulfuron with GA3, and sulfosulfuron alone. Glyphosate resulted in poor control overall. Compared to control plots the use of GA3 caused a slight increase in germination rates, but most notably increased the size of seedlings present. This suggests that weed control may be compromised if a lower rate of herbicide is used in conjunction with GA3. The use of both flumioxazin and pyroxasulfone and sulfosulfuron with or without GA3 gave great continued control of annual weeds, while still allowing native plants to return following a summer wildfire.

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Virtual Fencing of nursing cattle grazing large pastures of Chihuahuan Desert rangelands

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Abstract

Virtual fencing (VF) is an emerging technology to control livestock dispersal. This technology includes collars that employ auditory-electric pulse cues to deter animals from trespassing into excluded zones. Our objective was to investigate VF application on extensive rangelands. VF-trained nursing Brangus cows were grazed in a 480 ha pasture at the New Mexico State University's Chihuahuan Desert Rangeland Research Center with the VF-deactivated (control) or activated using three different polygon configurations. The VF-activated polygons excluded cattle from grazing either the East (209ha), West (200ha), or preferred Vegetation PV (80ha) within the pasture. Each pasture deployment lasted a week and the process was repeated on two groups of 11 and 18 cows, respectively. We analyzed 1) foraging behavior differences (control vs. VF-activated); 2) percentage of daily GPS locations within the excluded zones (control vs. VF-activated); and 3) number of auditory-electric pulses emitted during each VF-activated configuration (Excluded blocks East, West, or PV). The data were analyzed via an ANOVA to compare daily-derived variables. Cattle covered larger areas during control vs. VF-activated deployments (134.2 vs. 86.9ha P=0.04) with no differences in distance traveled nor cumulative activity index derived from the in-built motion sensors. When compared to the control, all VF-activated configurations significantly reduced the percentage of GPS positions within the excluded zone (East 52.27 vs. 0.67%GPS P<0.01; West 18.49 vs. 0.49%GPS P<0.01; PV 19.90 vs. 3.04%GPS P<0.01; control vs. VF-activated respectively). Significantly (P<0.01) higher audio and electric pulses (2.09, 0.51 respectively) were emitted during the PV trials compared to East (1.12, 0.17) or West (1.12, 0.14) blocks. In conclusion, VF holds promise in controlling spatial exploration patterns of cattle in extensive rangelands. Polygon configuration requires further research to understand trade-offs between animal welfare and effective management.

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Climate change beliefs, decision-making and adaptation behaviors of Western US ranchers

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Abstract

Rangelands cover over 50% of the land surface area in the western US, providing important economic, social and environmental benefits. The resilience of western rangelands, however, is increasingly threatened by climate change and related impacts, including altered phenology and precipitation patterns, increased frequency and intensity of drought and forest fires, heightened pressure from invasive plants, and reduced water storage in winter snowpack. Many climate adaptation strategies are available to ranchers. Uptake of these strategies, however, varies substantially. We conducted semi-structured interviews in Idaho, Montana and Oregon to examine how ranchers experience, conceive of, and communicate about climate change, and the opportunities and barriers these social processes create for climate change adaptation. We find that although they are generally skeptical of climate science, ranchers engage in a suite of climate change adaptation practices over time, including flexible and proactive grazing management practices, increasing plant cover, consulting drought forecasts and managing heat-adapted livestock breeds, yet investment in long-term adaptation remains limited. Producers tend to react to climate crises as they occur, in the short term, rather than planning for these occurrences to continue to increase and intensify across longer time horizons. These results show that climate change beliefs alone may have limited impact on producers' adoption of mitigation practices, suggesting that producers may be motivated to adopt mitigative practices by reasons beyond beliefs and engage in adaptive strategies in spite of climate change skepticism. We anticipate that these findings might be used to design and evaluate programmatic interventions aimed at increasing rancher capacity to adapt to climate change. Our findings have the potential to directly inform policy and decision makers because they provide a better understanding of how to best build climate adaptation capacity among ranchers.

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The effect of microsite management on native grass establishment and survival in a rangeland restoration

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Abstract

Rangeland restoration across the western United States is a critical endeavor since many rangelands have become low-diversity sites with diminished ecosystem services. Across the western US, rangelands have been buffeted by overgrazing, drought, fire, and annual grass invasion, resulting in the loss of bunch grasses, the dominant functional group of these systems. The resulting decline in ecosystem services and biodiversity have made restoration a priority. One key need is to get native bunch grasses back in the system, but efforts have met with limited success. While large-scale restoration actions can have a significant influence on species establishment and community resilience, there is also potential for small-scale, microsite management actions to drive species and community responses. We asked whether managing the microsite—through seeding within furrows and using pre-seeding treatments—increased the recruitment and survival of native grasses. Focusing on nine native grass species to the western Great Plains, we designed a factorial experiment with the treatments of planting method (drill seeded on the soil's surface or drill seeded in a furrow) and pre-seeding coating (agglomerated, primed and agglomerated, or untreated). Furrows have been shown to have significantly higher soil moisture, a critical resource for newly emerged grass seedlings. Agglomeration has been shown to provide additional soil nutrients; priming provides a trigger for germination. We found a high degree of species-specific responses to both the furrowing and to pre-seeding treatment. While a majority of species had greater emergence and growth when seeded within the furrows, one species, *Andropogon gerardii*, had greater emergence when seeded on the soil surface. These results indicate that the restoration of rangelands will require the consideration of species-specific responses to different management techniques. In addition, following the growth and survival of these species will provide insight into the long-term impact of these microsite management actions.

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Grazing selection preference of cattle over time in paddocks at the Nebraska Sandhills in 2016 and 2017 seasons

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Abstract

Cattle grazing behavior is an important component for grazing management and can be affected by environmental conditions, cattle preferences, and grazing management decisions. By tracking cattle using global positioning system (GPS) on rangelands, previous studies reported that cattle grazing behavior can respond to herd size, paddock shape and size, fence designs (e.g., physical or virtual), water source and shelter locations, and weather especially the variability in precipitation and temperature. Intra- and inter-annual environment changes can occur rapidly, and particularly, rangelands become more complex as impacted by regional weather variability, which may drive frequent changes in cattle grazing behavior. More studies are needed on understanding grazing selection preference and its changes affected by weather variability during grazing season. We hypothesized the variables influencing cattle grazing selection preference for a location would be changing throughout early-, mid-, and late-grazing periods as season progressed with higher temperature and decreased precipitation. With GPS data from cattle tracked at Nebraska Sandhills and environmental data (e.g., topography, vegetation) in 2016 and 2017, we built resource selection function models for each grazing period to determine significant variables that influenced grazing selection preference at a location over time in paddocks. Next, we examined the link between changes of variables and seasonal precipitation and temperature variability to investigate the impacts of weather variability on grazing selection preference. Preliminary results indicate that grazing selection preference was driven by multiple variables that were changing as season progressed. Vegetation condition (e.g., available biomass estimates) expressed by Normalized Difference Vegetation Index (NDVI) was significant throughout most grazing periods. Distance from a grazing location to water became more significant in mid- and late-grazing periods, probably due to greater temperatures influencing cattle behavior. Our study provides better understanding of cattle grazing behavior over time and space to support implementation of more adaptive grazing strategies.

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Geothermal energy production impacts a sensitive indicator species within sagebrush ecosystems in western North America

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Abstract

Growing demand for renewable energy has resulted in expansion of energy infrastructure across sagebrush ecosystems of western North America. Geothermal power is a growing renewable energy source in remote areas. Despite its potential, little is known about the impacts it may have on local wildlife populations. Investigations are warranted given similarities to more conventional surface disturbance activities with well-documented impacts. We used a novel 2-pronged analytical approach to investigate geothermal impacts on greater sage-grouse (Centrocercus urophasianus), an indicator species for sagebrush ecosystems. Using state-space models, we applied a before-after-control-impact-paired (BACIP) design to model changes in population growth (λ) and absence rates from sage-grouse lek surveys in relation to two geothermal development sites in Nevada, USA. Secondly, we explored geothermal development influences on demographic rates, and applied a population matrix model to spatially predict population changes at potential sites. Modeled λ declined by ~24% up to 5 km from development, while complete absence rates increased by ~730% within 2 km of development, relative to larger distances. Survival estimates were reduced for individuals occupying areas near geothermal infrastructure, but results suggested that impacts from operations could be partially offset by topographic barriers. We demonstrated complex effects on nest survival, wherein survival increased with increasing distance from geothermal infrastructure at low raven densities where topographic impedance was relatively high (three-way interaction). Our results collectively demonstrate reduced population performance up to 5 km from geothermal development. Results are applicable to future geothermal energy development when objectives involve minimizing adverse impacts to wildlife. Findings are preliminary and provided for timely best science.

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A science-based management of ravens tool (SMaRT): A 3-tiered hierarchical framework

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Abstract

Common raven (*Corvus corax*) population growth and distribution expansion across much of western North America is causing more frequent negative consequences to agriculture, human health and safety, and sensitive species. Traditional raven control efforts focused on the use of lethal removal, with little or no post-treatment monitoring. This approach has led to management plans that often fail to consider alternative management approaches, which may be more effective for achieving long-term predation management goals. We describe an adaptive management framework for addressing overabundant raven populations that explicitly incorporates peer-reviewed products. Our off-the-shelf Science-based Management of Ravens Tool (SMaRT) provides a user-friendly, web-based interface that guides managers through the steps of the framework to develop a fully customized adaptive plan for raven management. In the SMaRT interface, users can: (1) interact with existing maps of raven occupancy and density, input areas of interest or upload pre-defined polygons for target species within the Great Basin to delineate their proposed monitoring or treatment sites; (2) generate raven densities using a rapid assessment function; (3) compare site-level density to an identified ecological threshold; and (4) produce a list of potential management actions for their consideration. SMaRT supports decision-making by operationalizing literature and datasets within the field of raven management and facilitates meeting goals associated with sensitive species conservation. Findings are preliminary and provided for timely best science.

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Linking resource selection to population performance to identify species' habitat across broad spatial scales: an example of greater sage-grouse in a Distinct Population Segment

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Abstract

Particularly in rangeland ecosystems where managers must balance multiple different land uses, limited time and resources necessitate accurate identification of high-quality habitat for informing management decisions related to species conservation. Habitat selection is not always adaptive and integrating both selection and demographic performance while evaluating where these factors overlap can help guide species management. We demonstrate a quantitative approach to differentiate source and sink habitats at large spatial scales using the greater sage-grouse (*Centrocercus urophasianus*), an indicator species for sagebrush ecosystems. We evaluated both selection and survival across multiple reproductive life stages (nesting, brood-rearing) to better understand the interplay between these two responses in the Bi-State Distinct Population Segment, a genetically distinct and geographically isolated population on the western edge of the species' range. Our approach allowed us to identify mismatches between selection and survival and also identify potential trade-offs between life stages. Moving beyond designating important habitat solely based on species occupancy or use by incorporating demographic measures allows management actions to be tailored to specific scenarios. Examples include protection of source areas that support high selection and high survival, or restoration actions that focus on increasing survival in areas of high selection and low survival. Information is preliminary and provided for best timely science.

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Building Capacity to Reduce Human-Wildlife Conflict

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Abstract

Due in large part to legal protection, the gray wolf population has expanded for over 2 decades- therefore, in an effort to sustain co-existence, ranchers in the Northern Rockies have implemented a variety of non-lethal tools and management strategies to reduce wolf-livestock conflict. California is seeing a rise in confirmed wolf kills, as the state is home to 3 breeding packs along with dispersing individual wolves in the northeastern portion of the state. In addition, unlike many other western states, California has a limited population of large, wild ungulates which potentially escalates wolf-conflict for livestock producers. The ranching community and resource agency staff are looking for solutions to reduce future conflict, particularly from ranchers who have on-the-ground experience adapting their operations to wolf presence. The integration of non-lethal livestock protection tools, that are applicable on extensive, multiple use landscapes, holds the potential to minimize ongoing human-predator conflicts in California.

This Western Sustainable Agriculture Research and Education (SARE) professional development grant funded project is building internal capacity from first-hand knowledge, experience, and connections between University of California Cooperative Extension (UCCE) advisors and California ranchers, with ranchers in Idaho and Montana through tours and hands-on experiences. The multi-faced training and extension of information is leading to the integration of sustainable production practices and promotion of economic viability of California ranchers coexisting with a growing wolf population along with other predators (e.g. bears and lions). The project is building upon local extension efforts supporting interest from concerned ranching clientele that are facing increased predator conflicts. This project illustrates the value of training the trainers and industry leaders to assist a broader ranching clientele adapting to changing environment and supporting rural communities.

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How Proper Grazing Management Can Improve Water Security

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Abstract

In 2004, grazing management changed on the Humboldt Ranch (380,000 acres) in Northern Nevada. Change went from season-long (March to November) set stocking rate to managing length of rest for recovery. Both grazing management practices are within the terms and conditions of the allotment plan. The new grazing management is based on the goal of having 5 or more years of active growing season rest during a decade. The result of this protocol is best demonstrated by the recovery of the riparian vegetation. This recovery has been documented in many ways. Traditional on the ground riparian surveys, repeated ground photography, helicopter video of all 140 miles taken in 2004 and then drone imagery taken in 2022, and remote sensing every year starting 10 years before grazing management change. These assessments show a dramatic change throughout the ranch. Riparian vegetation has increased over 10 times, new segments of streams are flowing water year-round and beaver ponds have increased from a few to over a hundred. This is despite the severity of the regional “mega drought”. Ironically, in 2002 both Lake Powell and Lake Mead were full and now their levels threaten the security of communities that depend on them. While the ranch’s waterways are providing food, shelter and security for all the animals and the ranchers that depend on their proper function.

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Long-term adaptive management trends on USFS Region 3 grazing allotments

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Abstract

Adaptive management (AM) is a popular management approach in the field of natural resources and rangeland management. It is a method of decision-making that aims to reduce uncertainty in the face of environmental complexity to ultimately improve ecological, economic, and social outcomes. Despite the promise of this approach, AM has been difficult for natural resource managers and researchers to define and analyze, making large-scale assessments of its effectiveness challenging. Our research attempts to fill this gap by analyzing a large-scale implementation of AM by the United States Forest Service (USFS). In 2007, the USFS implemented a policy requiring the use of AM for all grazing permits on grazing allotments in Region 3 (Arizona and New Mexico). There is little known about how this policy has been carried out in USFS Region 3 and how it has affected outcomes. We aimed to understand if and how AM has been implemented on grazing allotments and how management has changed as a result by analyzing USFS compliance documents from 1996-2017. Allotment management plans (AMPs) and annual operating instructions (AOIs) (n~2400) from nearly all forests and selected districts in USFS Region 3 were coded to create a database including key management metrics that allowed for an analysis at the regional scale. Preliminary results of our data shows that certain AM indicators are observed in documents at increasing rates over time, especially after 2007. However, indicators of AM did not necessarily correlate with physical changes in management observed in compliance documents. Nevertheless, results from this study can help us understand both our interpretation of on-the-ground AM, as well as improve future decision-making and policy implementation with the increased knowledge of how and where AM is being carried out on Southwestern USFS rangelands.

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Urban Fire Implications on Livestock Grazing

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Abstract

Commonly, wildfires have burned forest and range landscapes. The Camp Fire and other recent fires across the state of California (e.g., Dixie Fire, North Complex, Carr Fire in Redding; Tubbs Fire in Sonoma, Lake, and Napa Counties) have also burned vehicles, homes, municipal infrastructures and businesses. As a result, the surrounding communities have been blanketed in thick smoke and falling ash, prompting local warnings to residents of unhealthy air quality. Locally based Cooperative Extension Advisors were alerted by clientele of concern about the potential impacts of the ash load on the feed their livestock were consuming, especially relative to the numbers of burned structures containing unknown levels of contaminants. Additionally, water quality concerns have arisen due to the nature of the urban fires at the top watersheds and potential water contaminants released from an array of burned materials. UC Cooperative Extension investigated forage and water quality impacts to address the immediate and near-term concerns of agricultural producers in the watershed below the Camp Fire. The findings from this project have informed concerned livestock producers impacted from subsequent urban fires in California.

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Estimating spatiotemporal trends of sage-grouse population abundance within stochastic environments: six decades of declines across the American West

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Abstract

Greater sage-grouse (*Centrocercus urophasianus*) population performance is at the center of western US rangeland use policies, largely because the species' unique life-history cycle which relies on a diversity of sagebrush ecosystem components. Oscillations in sage-grouse population abundance, driven by environmental stochasticity, present significant challenges to trend estimation. Using a Bayesian state-space hierarchical model and novel, trend-estimation approach, we overcame such challenges and derived range-wide population trends over different spatiotemporal scales relevant to sage-grouse ecology during 1960–2021. Models estimated 2.9% average annual range-wide declines, though percent declines varied among regions and sub-populations. Cumulative declines were 42.5, 65.6, and 80.1% across short (19 years), medium (35 years), and long (55 years) temporal periods, respectively. Two regions (Eastern Range and Bi-State Area) experienced growth during 2020 and 2021, suggesting they have begun a new population cycle. Models predicted 57.0% of populations exhibited >50% probability of extirpation by 2060. As a causal case study, we investigated interactions between wildfire and climatic conditions, and concluded inter-annual population fluctuations were primarily governed by precipitation while loss of habitat from wildfire prompted long-term declines by reducing environments' carrying capacity. We also compared trends among varying levels of sagebrush ecosystem integrity (SEI), as defined within a recently released interagency national conservation design strategy. Models indicate long-term population growth with strong levels of cyclicity in high SEI, while areas of relatively low SEI were less cyclical and declining rapidly. Our findings support maintenance of core populations with high quality habitats that buffer against stochasticity. Lastly, we developed a user-friendly web-based application tool for land and wildlife managers to access trend outputs across spatiotemporal scales and facilitate planning and execution of conservation actions and policies aimed at maintaining and creating viable sage-grouse populations. Some findings are preliminary and provided for best timely science.

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Sagebrush survival following spring prescribed fire at the ecotone of sagebrush steppe and mixed-grass prairie in northeastern Wyoming

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Abstract

When multiple ecoregions with varying historic fire frequencies intersect, managers face difficult decisions on if, when, and how to introduce fire to the landscape to maintain the overall regional plant community. At the ecotone of sagebrush steppe and mixed-grass prairie, wildfire promotes the mixed grass prairie components over the sagebrush steppe components through the removal of Big Sagebrush (*Artemisia tridentata*). Fire can also control juniper (*Juniperus virginiana*, *Juniperus scopulorum*) encroachment from riparian drainages within this region. However, because Big Sagebrush is a non-resprouter, the sagebrush steppe plant community can take decades to recover following fire which has negative implications for maintaining Greater-Sage Grouse habitat. Low-intensity prescribed fire may be a useful tool for managers to control juniper encroachment and promote perennial grass forage production without completely removing Big Sagebrush from the system. Big Sagebrush survival following two spring prescribed fires was examined immediately and four months post-fire on Thunder Basin National Grassland in northeastern Wyoming in 2021 . Prescribed fire effectively removed decadent dead sagebrush but also removed 60-80% of live sagebrush. Sagebrush individuals that were scorched but not completely consumed by fire typically died within 4 months following fire. However, pre-fire removal of fine fuels around sagebrush increased individual sagebrush survival. Spring prescribed fire conditions and fine fuel modification through pre-fire grazing and/or mowing can create a heterogenous burn in the sagebrush steppe and mixed-grass prairie ecotone. Big Sagebrush mortality was significant in spring prescribed fire but patches of individuals survived which could serve as seed sources to sustain Big Sagebrush population recovery in future decades. Low-intensity spring fires under conditions that can produce heterogenous burns may be a tool for managers to control undesirable woody encroachment, maintain grassland forage, and provide necessary reservoirs of Big Sagebrush individuals for their future population recovery.

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Bulbous Bluegrass, Friend or Foe?

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Abstract

Bulbous bluegrass (Poa bulbosa L.) is a short-lived perennial grass that is widely distributed and commonly found in disturbed or early-seral communities throughout the western U.S. Bulbous bluegrass primarily reproduces through asexual means and is one of the only grasses that has true bulbs. Similar to cheatgrass, it has invasive properties that allow it to be prolific and competitive in disturbed sites. However, the long-term impacts of bulbous bluegrass distribution in native plant communities, such as the sagebrush steppe, is unknown. Livestock grazing has been suggested as a tool that may reduce bulbous bluegrass, however, timing of livestock grazing will be critical. The objectives of this study are to: 1) identify knowledge gaps in bulbous bluegrass literature, 2) test the viability and vigor of bulbets relative to a collection date to address the timing of grazing on bulbous bluegrass to reduce bulbet production, 3) determine what temperature conditions are necessary for seed germination in the fall to help determine when grazing could be applied. We collected samples of bulbets four times, once each month (June-September), from the same population three miles south of Pocatello, Idaho. Total bulbet germination was evaluated for each monthly collection using a growth chamber set at 15°C with a 12-hr light duration (objective 2). August and September collected bulbets were also evaluated using temperatures of 0-, 5-, 10-, 15-, 20-°C with an 11-hr light duration to mimic fall germination field conditions (objective 3). Time to 25 and 50% germination were calculated, as well as total germination. Results from this study will increase our understanding of bulbous bluegrass phenology that can guide grazing practices that target bulbous bluegrass.

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In The Weeds: A Review and Synthesis Invasive Species Governance

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Abstract

Invasive species are a prevalent and intensifying 21st century environmental challenge. As distant places become ever more connected through movement of goods and people around the globe, non-native plant and animal species are provided new avenues to spread. Effective management of invasive plants requires not only knowledge of methods for control and eradication, but also knowledge of the factors that enable and inhibit coordination and cooperative—collective action—between disparate actors. In this study, we undertake a systematic review of the invasive plant literature and governance, while asking the following questions: “how much research has been done to understand the social and governance factors related to effective management of invasive plants? What aspects of governance has this research focused on? What are the gaps in the literature, and, based on these gaps, what are the most pressing future research needs?”. We based our search terms on the North American Invasive Species Network’s (NAISN) invasive plant list of 375 different species. This search resulted in 206,651 journal articles. We processed the articles through three different filters in order to determine articles were relevant to our research questions. Using this filtering process, we found that less than 1% of invasive plant literature explores themes of governance. In this presentation, we will share the results of our analysis of our comprehensive database of research on invasive plant governance and management, including common approaches to stakeholder engagement and collaboration, the reported effectiveness of different collaborative approaches, and gaps in knowledge.

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Assessing the efficacy of conservation efforts aimed at improving rangeland conditions for greater sage-grouse within the Bi-State Distinct Population Segment

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Abstract

Developing effective conservation monitoring and analytical frameworks that incorporate robust assessments of actions in relation to target species' viability is critical for successful recovery efforts. However, often it is difficult to quantify conservation efficacy because of the complex, dynamic nature of ecosystem processes and practical limitations associated with assessing target species' population dynamics. Here, we present an analytical framework that allows for quantification of conservation efficacy using greater sage-grouse (*Centrocercus urophasianus*; hereafter, sage-grouse) as an example. Our approach utilized a newly developed web-based repository of conservation actions within sagebrush ecosystems, along with other restoration databases within the Bi-State Distinct Population Segment bordering Nevada and California. State-space model estimates of apparent abundance served as inputs for a progressive change before-after-control-impact paired series modeling environment. Data from 57 leks and 85 unique conservation efforts implemented between 2012–2019 were investigated. Results provided evidence of conservation effectiveness based on an average annual increase of 15.8% in population abundance across the study area, and a 57.0% cumulative increase since 2012. Population gains varied by the type of conservation effort and according to the number of lag years following implementation. This project serves as a pilot study that is intended to be carried out across the entire species' range once data are available. These findings are preliminary and provided for best timely science.

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International Year of Rangelands and Pastoralists: Amplifying local voices through film

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Abstract

Film is a medium that many people appreciate in North America and throughout the world. It is often used to tell stories of places and peoples that are underrepresented on the global stage. For example, rangelands in many regions are considered “unusable wastelands” and, because the voices of the small rural populations that inhabit them go unheard, this narrative often goes unchanged. The designation by the UN of the International Year of Rangelands and Pastoralists (IYRP) creates an ever-greater impetus to promote the value of global rangelands and the people who live and work in them to a broader audience. The supporters of the IYRP have formed 11 regional working groups, with communications teams. The North American IYRP communications team (Canada, USA, Mexico) is working towards using films and film festivals as a way of informing the general public about the value of rangelands and pastoralists. In this talk, we will be highlighting past film production and festival efforts in Europe and Africa, and discuss efforts to create a film festival in North America. In particular, the North American IYRP communications team will present plans underway to host, first, a film festival or competition within our SRM community to build momentum within our organization, and then a larger North American festival inviting submissions from filmmakers within the general public to broadcast to a wider audience. Our goal is to showcase voices and perspectives from a wide diversity of people that work with and call our North American rangelands home.

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SMART WILDLIFE MONITORING: EVALUATING CAMERA TRAPS ENABLED WITH ARTIFICIAL INTELLIGENCE

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Abstract

Wildlife-livestock conflicts, including depredation, disease transmission, and resource competition, challenge the ecological and economic sustainability of ranches and farms, which in turn challenges the sustainability of wildlife that inhabit these areas. It is therefore important to continue developing ways to mitigate wildlife-livestock conflicts, particularly with economically and ecologically important species like elk, grizzly bears, and wolves. Timely and accurate information of wildlife presence would allow for the strategic application of conflict mitigation measures and help sustain critical wildlife habitat on working landscapes. Camera trap technology that uses artificial intelligence (AI) has the potential to provide real-time knowledge of wildlife presence, distribution, and spatiotemporal interactions between livestock and wildlife while limiting the amount of false positive triggers. We compared the performance of an experimental prototype, edge AI-enabled (“smart") camera trap against two commonly used types of non-AI-enabled camera traps (BROWNING and RECONYX). Ten camera traps of each type were deployed for a field test during mid-April–mid-September, 2022 on 4 ranches in south-central Montana, USA. One camera group composed of one camera of each type was deployed at 10 sites during spring and 10 different sites during summer. We collected a total of 707,266 images and compared the rates of positive detections, missed detections, and false positive images among the three camera types. We also evaluated the influence of environmental conditions on camera performance, including ambient temperature, wind speed and direction, precipitation, humidity, and herbaceous biomass. Complete results will be presented.

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Plant-soil feedbacks of Lehmann lovegrass (*Eragrostis lehmanniana*) and its effect on competition with native black grama (*Bouteloua eriopoda*)

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Abstract

Invasive plants can negatively impact rangelands by reducing plant and animal diversity, changing nutrient cycling, and increasing fire frequency. Lehmann Lovegrass (*Eragrostis lehmanniana*), a warm-season perennial grass from South Africa, was originally seeded in the southwestern United States in the 1930s to mitigate erosion and provide forage for cattle. It's still planted and valued in some areas; however, across many rangelands it has become invasive, altering the fire regime, and displacing native vegetation. *Eragrostis lehmanniana* is a prolific seeder, a strong competitor, and responds well to ecological disturbance. Furthermore, some evidence indicates that it can create plant-soil feedbacks (PSF) which benefit its growth relative to co-occurring vegetation. The purpose of this study was to explore the PSF of *E. lehmanniana* and its competition on native black grama (*Bouteloua Eriopoda*) by conducting a two-phase greenhouse study. Pots with pasteurized bulk soil were inoculated with soil collected from beneath either *B. eriopoda* or *E. lehmanniana* plants. Half of the inoculum from each species were pasteurized to create 'living' or 'dead' treatments. *E. lehmanniana* was then grown in the pots for 12 weeks in the conditioning phase, allowing the microbial community to proliferate. In the response phase, a replacement series competition, drought, and a fertilizer treatment were added. *E. lehmanniana* and *B. eriopoda* were grown out for 12 weeks, half being watered every 2 days and the others every 4 days. Additionally, half of the pots received fertilizer while the other half didn't. The log response ratio of biomass produced in pots inoculated with living vs. dead soil was used to assess PSF in the treatments and relative competition index was used to evaluate PSF effects on competition. Ultimately this research will help elucidate *E. lehmanniana* interactions with native plants and provide information crucial for rangeland restoration in *E. lehmanniana* invaded areas.

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Shrub encroachment effects on wildfire potential (incidence) in California's Wildland Urban Interface

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Abstract

Shrubs are a common component on California's Mediterranean rangelands. Shrub management was a common practice on rangelands until the 1980's but ended due to many different environmental factors. The cessation of shrub management has resulted in increased shrub encroachment on rangelands and foothills on the North Coast and Sierra Nevada ranges and more importantly, the shrubs are predominantly a single age class. The increase of shrublands, with predominantly old, decadent shrubs, has led to reduced habitat biodiversity and fuel loading on rangelands in both rural and urban areas. Urban areas have dramatically changed over the past forty years especially in the Wildland Urban Interface (WUI), with housing pushing further out and, in many regions, building in the foothills and shrublands. This dramatic change has set the stage for some of the worse fires in California's history, with the top eight largest California wildfires occurring between 2017 to 2021 have surpassed 300,000 acres; the top fire burning over one million acres. California's recent fires have become even more destructive, burning thousands of structures, for example the 2018 Camp Fire destroyed over 18,000 structures, completely destroying the entire community. All these more recent destructive fires occurred where the WUI encroached into shrublands. We used National Land Cover Database classification data from 2001 until 2019 along with the largest wildfires and most destructive wildfires in that timeframe to examine the impact wildfires have on vegetation, specifically to determine how quickly shrubs encroach post fire. We focused on what occurred in the rangelands: grassland/herbaceous, shrub/scrub, mixed forest, deciduous forest. We will share results as well as how this information could be used to make informed management decisions and potential policy changes to reduce fuels risk in the WUI in the future.

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INVASIVES DRIVING WILDFIRE: COLLABORATIVE UNDERGRADUATE DATA COLLECTION REINFORCES NATIVE AND INVASIVE POST-WILDFIRE SUCCESSION DYNAMICS

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Abstract

Wildfires are becoming more frequent and destructive in the Western United States. Human impacts on vegetation communities contribute to increased fire frequency and intensity; thus, understanding anthropogenic drivers of fire is essential to effective management. The Santa Monica Mountains, near LA, CA, experience a unique combination of climatic and anthropogenic stressors that make native vegetation communities especially vulnerable to abnormal fire regimes. Among these threats are conversion of shrubland habitats to ones dominated by invasive forbs and grasses, which often result from increased fire frequency. The Woolsey Fire in December 2018 was one of the largest wildfires in the history of the area. This wildfire burnt over 50% of the entire mountain range. We used this natural experiment to study the impacts of the Woolsey Fire and document post-fire recovery of native and invasive flora in the following six months. Undergraduate students from local universities and community colleges around Los Angeles monitored 36 sites for one to six months, starting in February 2019. Vegetation data were collected by 10 1x1m quadrats along a 100m transect and documented species presence, abundance, and burn severity from burnt shrub limb thickness. We identified species in plot photos in 2020 using student photographs and keys in local floras. Statistical analysis on 16 sites in February, 10 through May, has shown lower burn intensity associated with non-native species, particularly invasive species like annual grasses. We have also found evidence of type conversion showing increases in species richness immediately after the disturbance, mostly of fire-follower forbs and invasive grasses. These results could be important for land managers attempting to lessen the frequency of wildfires. Disturbed sites should be prioritized for restoration post-wildfire, and the most important times would be in February and March in the growing seed to lessen the seedbank of invasive annual species.

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Seasonal dry spell effects on primary production in Colorado grasslands

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Abstract

Climate change is bringing more frequent and longer dry spells (periods without rainfall) to much of the rangelands in the western US. While understudied, these drought patterns have potentially unique effects on our working lands. Understanding the consequences of prolonged dry spells and their timing on ecosystems and their interaction with grazing is critical to shape future management plans for resilient landscapes. To address this gap, we implemented three dry spells, early (May – early June), middle (early June – mid-July), and late (early July – mid August), with each removing about 30% of growing season precipitation. In half the plots we simulated a graze in June and early August. Each treatment was replicated across four sites covering a range of grassland plant communities located on the same soil surface south of Boulder, CO. We monitored belowground primary production, LAI (a proxy for ANPP), and NDVI throughout the growing season to assess short term and long-term effects on primary production. We found that early season dry spells had the greatest short-term effect on LAI. However, only the late season dry spell had a persistent effect on LAI at the end of the season. As we predicted, the effect of dry spell timing depended on the ratio of C3:C4 grasses. Plots with high abundance of C3 grasses showed a greater response to early dry spells. The early dry spell also decreased belowground biomass production by 50% during the dry spell. We saw little evidence for an interaction between dry spell timing and grazing on end of season LAI values from our preliminary analysis. Together our results demonstrate unique effects of prolonged dry spells and suggest that the impact of these can vary with community composition even at small spatial scales.

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A values typology to support decision-making in working landscapes undergoing change

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Abstract

Changes in the public's relationship with land management agencies have prompted increased research on public values for the land, attitudes toward its use and management, and the role of these values and attitudes in decision-making processes. People's preferences for how landscapes are used and managed can be informed by their values, experiences, and identity. Working landscapes undergoing social and ecological changes, such as the sagebrush steppe of Idaho, provide a useful case study for assessing the values that people hold for these landscapes and how they relate to attitudes toward the variety of management policies and strategies to address change. Population expansion, migration, and land use change are altering both the physical and social landscapes of Idaho's sagebrush steppe, which is susceptible to degradation from these changes, especially when coupled with the impacts of interconnected ecological threats. We aimed to (1) identify patterns and variation in values, (2) assess the relationship between these patterns, perceived threats, and management attitudes, and (3) evaluate the implications of these differences for management of these landscapes. We used a phone and web-based survey (n = 1,048) to measure values, perceived threats, and attitudes toward recreation and residential development governance in Idaho's sagebrush steppe. We clustered respondents and values using latent Dirichlet allocation, and then compared the perceptions of threats and management attitudes of the respondent clusters. We used multilevel regression and poststratification to produce county-level estimates for both the value clusters and management attitudes in order to assess the acceptance of different management actions at a regional scale. By understanding who holds what values and where, we are able to better inform regional decision-making for these imperiled landscapes. Altogether, these results contribute to our understanding of the relationship between values and attitudes toward decisions addressing social-ecological changes.

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Belowground Bud Banks: the impact of drought timing on the formation of meristematic tissues in two cool season grasses

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Abstract

Perennial grassland ecosystems rely on belowground meristems (i.e., bud banks) to resprout annually and following a disturbance (fire, drought, and grazing). Many native grass and forb species contain active and dormant meristematic tissues located just below the soil surface (bud banks). Asexual reproduction is the dominant mode of reproduction in perennial grassland ecosystems, so bud banks are a dominant control over annual production in many perennial grasslands. Climate change is projected to cause a global increase in drought frequency and intensity, decreasing productivity and ecosystem function. Therefore, understanding how drought impacts the early life stages of dominant perennial grass species is important in predicting the effect of decreasing water availability throughout the growing season on current and future rangeland production. To understand bud bank production in native grass seedlings, we grew two dominant cool-season grass species from seed at the Colorado State University Plant Growth Facilities. Once the seedlings had at least three leaves, we counted the number of buds present, bud size, tiller number, height, and developmental stage (juvenile vs. adult tillers). To investigate the effects of seasonal drought we imposed the following treatments: control, early drought, and late drought. The drought treatments were imposed until the tillers were visibly stressed (i.e. wilting or curling of leaves); at which time, a subset of the treated samples were harvested to record bud and tiller characteristics. The remaining samples were rewatered to monitor drought recovery and resprout. Samples in the second drought treatment took longer to show signs of stress, yet responses of bud banks to both droughts were variable. The effects of drought on bud bank development will have implications for perennial grassland production in future climate conditions. Future studies examining bud development in the field will be necessary to better understand grasslands will respond to increasing aridity.

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Acute Effects of Fire on Soil Carbon

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Abstract

Rangelands are significant reservoirs of carbon and offer the potential to accumulate additional atmospheric carbon dioxide, offering landowners added streams of revenue from land-based carbon credits. Prescribed fire to mangage rangelands, while common, the effect on soil carbon is less understood. The objective of this study was to evaluate acute effects of prescribed fire on soil carbon quantification metrics and whether effects of fire varied among ecological sites. NRCS ecological site descriptions were utilized to develop a stratified random sampling design within the study area (384ha). Sampling locations (n=10) were randomly placed within the strata in a plot slated for prescribed fire, and soil cores were collected from 5, 15, and 25 cm depths prior to and post burning. Bulk density (g/cm3) was measured for each sampled depth. Soil organic carbon and total carbon were analyzed on aggregated core samples using dry combustion by an independent laboratory. Differences between post- and pre-burning measurements of percent organic carbon ($\bar{x}$ =.033, range =-0.17 to 0.37), total carbon ($\bar{x}$ =0.001, range =-0.27 to -0.32), and bulk density ($\bar{x}$ =.014, range =-0.06 to 0.11) showed no significant effect (P = 0.20, 0.48, and 0.27 respectively) of burning. While differences of carbon measures between ecological sites were observed prior to burning, due to inherent spatial variability, the acute effects of fire did not differ among sites (P= 0.35). Confidence intervals for mean values of the change in pre- and post-burn measures of soil carbon and bulk density contained zero, thus no acute effects of fire were detected. Long-term effects of fire on vegetation dynamics and subsequent soil carbon accumulation or depletion were not evaluated. Results suggest that landowners may apply prescribed fire as a management tool while enrolled in carbon contracts with minimal acute impact on soil carbon.

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Who approves of livestock grazing? An assessment of Idahoans' changing views on rangeland issues

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Abstract

The United States' population has been moving westward, with states dominated by rangelands—and Idaho in particular—experiencing rapid growth. These changing population patterns contribute to increased recreational use of western rangelands and transitions away from economic dependence on ranching. Simultaneously, these dynamics are playing out against a backdrop of increasing political polarization and environmental change. Given these changes, we investigated whether public attitudes toward rangeland issues are shifting in Idaho. We leveraged longitudinal statewide survey data on rangelands in 2010 and 2014 and conducted new surveys in 2021 (n=1,048) and 2022 (n=616). We found that public approval of livestock grazing on public lands decreased by 12% between 2010/2014 and 2022. As in past years, political view was a significant predictor of approval. However, the drop in approval in 2022 was due almost entirely to an increase in people who responded that they "don't know" whether they approve, with women and those who had spent less of their lifetimes in Idaho significantly more likely to be unsure. Most Idahoans thought that wildfire risk reduction, wildlife habitat, and invasive species prevention should be given the highest priority when making decisions about public rangelands, above recreational opportunities and the economic well-being of communities. Views of the effects of livestock grazing on wildfire risk, wildlife habitat, and rangeland condition were also significant predictors of their attitudes toward public lands livestock grazing, with most believing that livestock have neutral to positive impacts. Thus, while demographic factors strongly predict the ways that people view rangeland issues, opinions about livestock grazing are also shaped by preferences for reducing wildfire risk and maintaining rangeland condition. Those who are newer to Idaho do not disapprove of livestock at higher rates, but they are less likely to have formed opinions about livestock grazing on public rangelands.

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Effects of large herbivore exclusion on big sagebrush (*Artemisia tridentata*) survival during drought in Utah's Colorado Plateau

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Abstract

Big sagebrush (Artemisia tridentata) ecosystems cover a significant portion of the western United States and provide important habitat for wildlife. Sagebrush in the southern portion of its range, on the Colorado Plateau, are at particular risk due to increasingly warm and dry conditions. Our study seeks to understand drivers of sagebrush death and survival in this region, over the course of a six-year period which encompassed extreme drought conditions. In particular we investigate the effects of large ungulate herbivory on sagebrush density, cover, and size.

Our study consists of 36 pairs of 100m2 - ~120 m2 plots distributed across three sites in San Juan County, UT. Half of each pair were fenced in 2016 to exclude large ungulates, including both livestock and large mammalian wildlife, while the remaining plots were unfenced. In 2022 we sampled shrub densities by size class, percent shrub death, and shrub cover .

Outside of exclosures, under ambient browsing conditions, densities of sagebrush decreased in the smallest size class (<15cm) and increased in all other size classes (15-50cm, 50cm-100cm, >100cm), suggesting that sagebrush plants transitioned into larger size classes over time. Inside of exclosures, densities of 15-50cm tall shrubs decreased significantly, and to a lesser extent so did densities of 50-100cm shrubs. These results suggest that, when protected from herbivory, intraspecific competition reduced densities of smaller (15-50cm) shrubs and also somewhat limited densities of larger (50-100cm) shrubs. Shrubs protected from herbivory also had higher proportions of live plant material . It appears that ungulate access – likely browsing wildlife and possibly interactively with drought – moderates intraspecific competition for sagebrush.

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Selecting grass species for grasslands restoration through environmental niche modeling

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Abstract

The implementation of grassland restoration programs has globally intensified over the last decade. In Mexico, most of these programs have failed, due to the poor establishment capacity of most of the grass species utilized for this purpose. Therefore, it is necessary to explore new grass species that may have greater establishment capacity and can be used to revegetate degraded rangelands. Thus, this study evaluated the potential distribution of 51 grass species by using the maximum entropy method, with the aim to select those with the greatest potential distribution. Initially, the 19 bioclimatic variables from the Worldclim database were obtained to perform the modeling. Then, Pearson's correlation test was applied to identify and exclude highly correlated variables (coefficient > 0.8). Only twelve bioclimatic variables showed a degree of collinearity lower than 0.8 in absolute values (positive or negative correlation) and were used for the species distribution modeling. Eighteen grass species were selected since they have a potential distribution greater than 75,000 km^2: *Bouteloua hirsuta* (120,596 km^2), *Bothriochloa barbinodis* (11,2217 km^2), *Aristida adscensionis* (102,388 km^2), *Paspalum distichum* (101,354 km^2), *Setaria parviflora* (100,251 km^2), *Setaria leucopila* (99,749 km^2), *Eragrostis intermedia* (97,290 km^2), *Leptochloa dubia* (95,330 km^2), *Setaria macrostachya* (95,189 km^2), *Digitaria californica* (92,611 km^2), *Aristida ternipes* (90,904 km^2), *Panicum hirticaule* (84,190 km^2), *Bouteloua barbata* (81,840 km^2), *Aristida divaricata* (81,726 km^2), *Aristida purpurea* (81,552 km^2), *Microchloa kunthii* (80,881 km^2), *Lycurus phleoides* (77,911 km2), and T*richloris crinite* (76,829 km^2). Results from this study could serve to select new grass species that can be used in grassland restoration programs. However, it is necessary to evaluate the performance of this species in the field and select those with a greater probability of successful establishment than the species currently used in restoration programs.

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Channel and Vegetation Response to Low-Tech Process-Based Restoration Structures

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Abstract

In arid regions, riverscapes and associated landscapes like meadows occupy a small area but provide an outsized role in ecosystem services, fish and wildlife habitat, and forage for livestock. Restoration of these landscapes through low-tech, process-based restoration (LTPBR) techniques such as beaver-dam analogues (BDAs) or post-assisted log structures (PALS) may provide landowners and managers with a low-cost and easily implemented approach. These LTPBR techniques are designed to modify the shape of incised stream channels by capturing sediment, raising the water table, and rewetting adjacent meadows. Yet, there are few studies showing monitoring approaches and the resultant outcomes to stream channels and meadow vegetation. Here, we summarize findings of a three-year LTPBR restoration project on two streams in Idaho. The project used drone-based aerial imagery to chart stream channel shape, water inundation, and vegetation productivity before and after the installation of the LTPBR structures. The team flew the drone at peak biomass each year and analyzed the imagery in Agisoft Metashape with a structure-from-motion technique. The software returns a point cloud, a 2.5D digital elevation model (DEM), and an orthoimage. Year-over-year change was calculated using a DEM differencing technique with Agisoft Metashape. The analysis of vegetation productivity used the green chromatic coordinate index obtained from the visible spectrum and analyzed in Agisoft Metashape. Water inundation was assessed using drone imagery and field measurements for pre-installation and post-installation sites. Results indicate that drone-based monitoring methods are sufficient to capture changes in stream morphology, water inundation, and vegetation productivity cased by LTPBR projects. This project explored different monitoring approaches and indicators useful for assessing the effectiveness of a novel stream and meadow restoration technique. While specific to two streams in Idaho, the techniques and approach will be useful for anyone interested in rangeland ecology and management.

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Applications of Virtual Fence Technology in Quantifying Livestock Resource Selection in a Semi-Arid Ecosystem

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Abstract

The application of precision agricultural techniques is of increasing importance in the development of sustainable food systems needed to meet the demands of a burgeoning human population. Critical to this effort is the need reassess the way in which livestock interface with and derive resources from their environment. The recent development of virtual fence technology provides a unique opportunity to examine principles of grazing ecology on a granular scale. This technology enables the application of a dynamic network of “fences” as livestock inclusion and exclusion zones. All “fences” are georeferenced via individual cattle collars and used to both monitor and influence animal distribution across a given landscape. We developed a resource selection model derived from individual collar locational data to better examine the relationship of livestock movement patterns and selection preference in response to environmental co-variates on the University of Arizona, Santa Rita Experimental Range. This bottom-up approach serves as a pilot model and will inform ongoing efforts by the UA Virtual Fence research initiative to better quantify the ecological interactions of livestock grazing in a complex semi-arid ecosystem.

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Mind the Gap: Citizen Preferences and Motivations for Invasive Plant Management

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Abstract

Invasive plant species, pose significant challenges to natural resources and communities around the world. Climate change and globalization have increased the spread and successful establishment of invasive plants, a trend that is expected to continue. Because of the ability of invasive plants to establish in spread in new habitats, successful management frequently requires collective action across land ownerships and stakeholder groups to implement management practices at a geographic scale large enough to stop spillovers and reestablishment of invasive plants from unmanaged areas. Here we present the results of a survey that asks the question: what motivates people to participate in management to mitigate or remove an invasive plant species from a landscape? To investigate this question, we conducted a survey of the general public in Tucson, AZ that applied two methods of measuring preferences and motivations for action. A choice experiment was used to measure revealed preferences and a protection motivation theory (PMT) model was used to test what factors are most effective for motiving willingness to act (behavioral intention) and actual behavior for management of a globally significant invasive grass species, buffelgrass (*Pennisetium ciliare*). Our findings show that those more directly impacted by buffelgrass are more likely to express preferences favorable of management, but that these preferences translate to actual actions only when people feel they are personally knowledgeable about the problems caused by buffelgrass, feel they are capable of implementing management activities themselves, and feel that these activities are effective. These findings are useful to managers seeking to motivate citizen engagement in invasive plant management.

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Developing Indian Ricegrass Seed Coating Technology for Great Basin Restoration

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Abstract

Indian ricegrass (Achnatherum hymenoides) is a highly palatable forage for livestock and wildlife; however, seed dormancy of this species often results in poor or failed plantings of this valuable conservation species. While dormancy strategies of Indian ricegrass are advantageous for the species' long-term survival, this strategy does not meet most restoration goals in the Great Basin, which requires germination in the first year after planting before invasive species occupy the site. Reducing seed dormancy of Indian ricegrass before planting may improve seeding success for this species. We used scarification to reduce physical dormancy and gibberellic acids (GA3) to reduce physiological dormancy. We also scarified seed in a mechanical scarifier and coated seeds with a slow-release polymer infused with GA3. Additionally, we applied a fungicide coating to protect scarified seeds from pathogens. In the spring of 2021, we planted a factorial combination of these seed enhancements (scarification, GA3, fungicide) along with untreated seeds. We used 2-m rows within a randomized block design in sandy soil near Provo, Utah. We analyzed the effectiveness of these seed treatments in a germination trial and a spring field planting. Scarification and GA3 coating both increased germination in the laboratory. In particular, seeds scarified for 10 seconds and then coated in GA3 saw a 43-fold increase in germination from the control ($p = 0.02$). However, the same treatments behaved differently in the field. Fungicide alone decreased plant density from the control, but fungicide paired with scarification and GA3 coating caused a 4.3 increase in plant density over untreated seed ($p = 0.02$). These results indicate that breaking seed dormancy and protecting the seeds from pathogens may improve Indian ricegrass establishment. Additional field studies are merited for evaluating the efficacy of the novel dormancy break treatments used in this study.

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Spatiotemporal changes to ecosystem services following shrub encroachment in a semi-arid grassland

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Abstract

Understanding the spatial aspects of ecosystem services (ES) is a necessary step in designing strategies for managing them under changes associated with land use/land cover change. Most research which has focused on quantifying or mapping ESs has ignored their temporal dimensions instead focusing on a single point in time. This approach provides only a static picture of the current provision of services and does not offer insights into the rates/dynamics of ESs and how they have changed through time. Ignoring the history of ESs may result in missed opportunities to foster synergies and avoid undesirable outcomes. While the case for temporal ESs studies is logical, studies of this nature are largely absent from the literature.

To address this gap in knowledge, we used high resolution (1-meter) aerial photography and satellite imagery from 1936-2017 to classify changes in Prosopis velutina (velvet mesquite) cover across a 18,200 ha rangeland in Southern Arizona. Velvet mesquite is a well-known invader in rangelands and presents one of the largest land cover changes to semi-arid grasslands across the Southwest. We then used these shrub cover maps to model the provision of three important rangeland ES, (i) soil erosion and runoff, (ii) critical wildlife habitat, and (iii) forage potential, through multiple points in time and analyzed how they have been altered with subsequent shrub encroachment. This poster will discuss these results as well as how such information can be used to better manage encroaching shrubs and meet conservation objectives for protecting ES.

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Livestock Pond Restoration: A climate resiliency solution to protecting listed species breeding habitat with livestock grazing management

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Abstract

Starting in the 1940's, livestock ponds were constructed throughout the rangelands of the Bay Area, California to collect surface water and runoff for livestock drinking use in hilly grasslands. With the loss of wetland habitat and continuous urban encroachment, these upland ponds have become critical breeding habitat for specially listed amphibian species like the California red-legged frog and the California tiger salamander. Livestock grazing has been shown to provide beneficial upland vegetation and aquatic conditions for wildlife. The ponds are turbid with little emergent vegetation that have very low plant cover in the surrounding uplands which help the amphibians migrate from the rodent holes and soil cracks to the wetland features.

With the lack of maintenance overtime, some ponds have suffered from structural damage or filled with sedimentation reducing the hydroperiod. This results in both inadequate livestock water and suitable breeding habitat. With the help of the NRCS Wildlife-friendly Livestock Pond Restoration program in Alameda and Contra Costa counties, local public lands agencies, partners, and grazing tenants have participated and restored a number of ponds. These efforts have proven to be successful in improving both wildlife habitat and grazing management. They are looked at as a climate resiliency projects as they concentrate in enhancing the hydroperiod which may be key during times of prolonged drought or other extreme climatic events.

The synergistic relationship of grazing and aquatic breeding habitat is an unusual one that should be highlighted, along with the partnership amongst government agencies, ranchers, and public recreation land districts.

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Targeted grazing in California grasslands increases native annual forbs and reduces fine fuels

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Abstract

California grasslands experience a Mediterranean climate with inconsistent rainfall, have variable topography, heterogeneous soil types, and tend to be more forb dominated than other North American grasslands. Today, these grasslands still host native perennial grasses and annual forbs, but are now largely dominated by invasive annual grasses. Although these systems did not host large native grazers, they have been extensively grazed by cattle for the past two hundred years. Despite this, the effects of cattle grazing in California grasslands has been difficult to investigate, with studies being confounded by different grazing regimes (e.g. seasonal, rotational, or year-round stocking practices) or limited study time frames, which has led previous investigations to fail to encompass California's variable climate and diverse topography. As grazing is being considered for habitat and fuel management objectives throughout California, it is critical that rigorous methodological studies that assess the efficacy of targeted conservation grazing are conducted, evaluated, and shared to guide practitioners. We report on an eight year study where we test the vegetation effects of a targeted grazing regime, which implemented conservation goals, prescriptions, and monitoring practices. We found that our targeted grazing regime reduced litter depth, litter cover, and herb height, while increasing native annual forb cover. We observed no significant change in other species groups, including non-native species groups. This study provides important insight on the long-term impacts of targeted grazing on coastal grassland vegetation composition and provides a strategy for adaptive management that allows land managers to further target conservation outcomes in California grassland habitats.

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A living lab for the Canadian Prairies

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South of the Divide Conservation Action Plan, Eastend, Canada

Abstract

Agriculture and Agri-food Canada's Living Labs initiative moves research from plots to working landscapes, to better understand and support adoption of BMPs (beneficial management practices). The Central Prairies Living Lab will assess grazing and grassland management practices in the moist and dry mixed grass and aspen parkland ecoregions of Saskatchewan. Project collaborators will manage grazing impacts in rotational, deferred, seasonal, and other grazing systems; retain, restore and rejuvenate perennial plant communities; and plant diverse annual polycrops for livestock grazing. Researchers will investigate effects on soil carbon, forage quantity and quality, forage and range condition, animal performance, greenhouse gas emissions, water, wildlife, and economic and social parameters. Together, stakeholders will interpret findings and formulate practical recommendations for how to achieve agri-environmental benefits in the prairie ecoregions. The project will promote and track producer adoption and attitudes about BMPs, and will establish a network for sharing experiences and resources. This work will improve understanding of the value of grazed grasslands, and identify and accelerate adoption of locally appropriate BMPs.

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The Prairie Project: Learning about Woody Brush Encroachment Outside the Classroom College Station, USA.

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Abstract

Upon the influx of European settlers in the 1850’s, the Southwestern Great Plains (SGP) experienced a rapid takeover of woody plants. Woody plant encroachment (WPE) has been disrupting the hydrology, biodiversity, production, and overall nutrient cycling of rangelands. However, tools and techniques such as prescribed burning, patch-burn grazing, and pyric herbivory offer a cost-effective, long-term solution to help manage and prevent these woody invaders from spreading. In addition, new technology applications such as the Rangeland Analysis Platform (RAP) has been created to help assist in the managing/monitoring of America's rangelands. Educational and outreach curriculum was developed to assess adult and youth knowledge and understanding of WPE management of cover estimates across 4 demonstration ranches in West Texas using both the RAP and vegetation monitoring transects. Participants used the RAP to analyze the effects of specific management practices like prescribed fire, patch-burn grazing, and multi-species grazing on grasses, forbs, shrubs, and tree cover. In addition to participants using the RAP, ground-truthing vegetation transects were conducted to determine cover estimates in the same pastures on the 4 demonstration ranches in order to compare the values generated by the RAP. Participants were given the opportunity to compare both techniques in the curriculum discussing implications for WPE management and adoption of studied practices. Participants consisted of extension agents, high school educators, college students, Texas Master Naturalists, Texas Section Society for Range Management Youth Range Workshop (YRW), Ranch Brigades (RB), and 4-H/FFA youth. Youth from YRW, and RB experienced the highest rates of knowledge gained at 18% and 25%. The second highest rates of knowledge gained occurred with the extension agents and college students at 7%. Lastly the groups that experienced the smallest to no amount of knowledge gained were the 4-H/FFA youth and the Texas Master Naturalists group at -.6% change.

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Free-Roaming Horse and Burro Sustainability Triangle

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Nevada Section FRHB Committee, Reno, USA

Abstract

Sustainability requires environment, economics and culture. Bureau of Land Management and Forest Service have been managing free-roaming horses and burros (FRHB) since the 1971 Wild and Free Roaming Horse and Burro Act. They began without the legal, personnel, or knowledge infrastructure needed to accomplish this new mission and populations soon doubled. Progress for decades ended, without a clearly stated vision for FRHB Program sustainability, when costs were escalating for off-range holding of gathered horses. Cutting budgets led to far greater long-term costs. The number of horses and burros that enable a sustainable thriving natural ecological balance and multiple use relationships is the appropriate management level (AML). AML is driven by the ecosystem resilience and habitat needs for wildlife, horses and other multiple land uses. Size of horse and burro populations times their reproduction rate determines annual population growth. Law and sustainability require gathering excess horses, those above AML. By gathering and removing excess animals, those between low and high AML, all excess horses and burros can be adopted every year. Adoptions vary between about 5,000 and 7,000. If removed animals are young, they are more adoptable. When herds are above AML excess horses are too numerous for all to be adopted. Unadopted horses must be cared for at government expense - whereas public agency costs for adopted horses are minimal. AML is essential for thriving natural ecological balance, keeping costs from escalating, and keeping horses and multiple use rangelands healthy. Had we gathered to (AML) and placed 6,570 more horses into long-term holding in 2007, 30,000 fewer horses would be in long-term holding today. Although the cost today for getting to AML seems great, getting to AML as soon as possible and staying there is the least cost non-lethal approach to FRHB management. And fertility control after AML reduces gathering.

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Western Healthy Lands - An Approach for Sustaining Free-Roaming Horses, Burros, Habitats, Ecosystems and Multiple Land Uses

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Abstract

Reproduction of excess free-roaming horses and burros leads to excess costs. Excess horses and burros are those above appropriate management level (AML), the number of horses and burros that enable a sustainable thriving natural ecological balance. When horses are too numerous for adoption demand, unadopted horses go to off range holding at government expense. The high proportion of the FRHB program expenditures for off-range holding has motivated a focus on fertility control for herd size management. Unfortunately, when herds are substantially above AML, fertility control is not effective at avoiding growth of excess horse numbers and their impacts to wildlife, horse habitats and multiple other ecosystem attributes and land users. Relying on fertility control now increases the number of horses that must be gathered, even for fertility control. Fortunately, by gathering and removing excess animals and getting to AML, the excess horses and burros, those between low and high AML, can all be adopted every year. Prolonging getting to AML by gathering only slightly more FRHB (20,000/year) than are produced each year and doing so for a large number of years requires placing very many horses into off-range holding. Getting to AML quickly by gathering many more horses (30,000/year), causes the number of horses in off-range holding to peak in half the time and then decline as gathered horses live out their lives without replacement. The key to cost saving is getting to AML quickly and staying there with sufficient and continuing gathering/removal of excess horses and burros -- many until AML - then far fewer, but enough (all excess and adoptable) to maintain AML. With this Healthy Western Lands approach, fertility control treatments after AML can become effective at further reducing the rate of adoptions needed. Permanent or long-lasting fertility control could further reduce the need for gathering.

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Contrasting Grazing Management for Livestock Versus Free-Roaming Horses and Burros

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Abstract

Objectives for management vary across a great diversity of ecological sites in ranches and pastures that vary widely in their size infrastructure, rangeland health issues, opportunities for forage production and for changing range condition or health. Thus, rangeland livestock grazing management strategies vary widely, including foci on season of use, duration of use, season and duration of rest or recovery periods without grazing, selection of the kind and class of grazing animal, rotation or variation of the grazing periods among years, and the intensity of use during the grazing periods as evaluated with utilization, stubble height residual dry matter or level of woody use. Tools for effecting the strategies include fencing of many types and layouts and water developments as well as stockmanship and the use of salt or supplements for shifting animal use within pastures. Most of these tools and strategies are not relevant for management of free-roaming horses and burros. The 1971 Wild and Free-Roaming Horse and Burro Act focuses on maintaining carrying capacity with proper stocking rate. Appropriate management level (AML) defines the number of animals that can graze and maintain a thriving natural ecological balance and multiple use relationships. Excess animals, those above AML are to be gathered and hopefully adopted or if not sent to off-range holding. Unfortunately, AML has not ever been achieved for the national population and most herd manage areas usually exceed AML. Nationally, stocking rate in 2022 is more than three times AML. While set stocking is also used with livestock in some pastures, it can lead to overuse of hot spots especially in hot moments such as green riparian areas when upland forage has become brown. Managing hot spots and hot moments by adjusting stocking rate without other strategies is not efficient, but is necessary for large free-roaming herbivores.

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Sustaining Riparian Functions with Management of Livestock and Free-Roaming Horses and Burros

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Abstract

As rangeland managers and stakeholders have learned of the importance of riparian areas for biodiversity and for watershed, water catchment, processes, riparian grazing management has generated much conflict. Fortunately, we have learned to focus on riparian functions. Knowing that riparian proper functioning condition is important and quite possible has resolved many conflicts. The tool shed is well stocked with tools and strategies for managing grazing to restore or keep riparian areas functioning properly, or to meet objectives. Perhaps of greatest importance is the movement of animals to provide prescribed periods of use and time for rest or recovery when not grazed. Recovery with an abundance of water allows riparian areas to be very resilient. However, season-long use of large pastures with small riparian areas causes prolonged periods of concentrated riparian grazing and loss of stabilizing vegetation. Then riparian areas cross ecological, geomorphic and hydrologic thresholds with dramatic impacts on forage productivity, habitats, wildlife diversity, water quality, and resilience. While adjusting stocking rate is a weak expensive tool for avoiding or fixing these livestock grazing problems, it is the only tool available for management of free-roaming horses and burros. Thus, managing herds for an appropriate management level that maintains a thriving natural ecological balance and multiple use relationships is essential, but has rarely been accomplished. Where both livestock and free-roaming horses graze together, it is essential to monitor the strategies that work - movement of animals or season and duration of grazing and of recovery periods for livestock, and grazing intensity in key or critical areas including riparian areas for free-roaming equids.

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Impact of Large Herbivore Use in Meadows on Lentic Function, Wetland Extent and Vegetation Hydric Status

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Abstract

Wild horses and livestock disproportionately favor riparian areas over uplands. Long-term trampling can damage riparian roots, shrinking meadows. The authors examined grazing variables of timing, duration, and intensity, based on the focus provided by the Grazing Response Index (GRI) to consider opportunities for plant growth. Trail cameras captured relative amount of livestock and wild horse use at meadows with sage-grouse late-brood rearing habitat potential. Lentic riparian proper functioning condition assessments indicated all study sites have shrunk, have altered flow patterns, and were functioning at risk. Locations grazed by horses and cattle, had longer duration of grazing for horses than cattle.

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Early succession after prescribed fire in low sagebrush steppe

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Abstract

We assessed plant community recovery following prescribed fire on *Artemisia arbuscula* [CSM1] Nutt. (low sagebrush) steppe in southeastern Oregon. Treatments were prescribed burned (Burn; fall 2012) and unburned (Control) *A. arbuscula* steppe. The study design was a randomized complete block with four replicates per treatment. Herbaceous yield, cover and density were compared between treatments (2012-2020). Fire largely eliminated *A. arbuscula* and there was no recruitment of new plants the first eight years after fire. Herbaceous yield in the Burn treatment was double the Control for the post-fire period. Perennial grasses and forbs comprised 94 to 96 % of total herbaceous yield in the Control treatment. In the Burn treatment, perennial grasses and forbs comprised 83 to 87 %, native annual forbs 2 to 5 %, and *Bromus tectorum* 3 to 9 % of total herbaceous yield. Despite the increase in *B. tectorum*, burned *A. arbuscula* sites were dominated by perennial grasses and forbs and exhibited high levels of resilience and resistance. For comparable A. arbuscula associations, weed control or seeding are unlikely to be required following fire.

[CSM1]Would it be worth clarifying here or elsewhere the subspecies? I'm thinking that some people may still get a bit confused with other subspecies they may be familiar with, like Alkaline (longiloba), with different habitat characteristics

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Grazing an Ecotone in a Warmer World - Assessing the Vulnerability of the Thunder Basin National Grassland to Climate Change

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Abstract

Climate change and increasing climate variability pose unprecedented threats to rangeland ecosystems in North America and the ranching communities that depend on them. We conducted a climate change vulnerability assessment of the mixed-grass, shrubland steppe ecotone of the Thunder Basin National Grassland in northeastern Wyoming, including its implications for public and private rangeland managers. This 7,000 km^2 region hosts plant communities representing an ecotone between Big sagebrush (*Artemisia tridentata* subsp. wyomingensis) steppe and Northern mixed-grass prairie, which acts as a biodiversity hotspot and a vital livestock producer in the western Great Plains. Understanding ecotone vulnerability is critical because these transition zones are susceptible to global change agents, including land use change and climate change. Through an extensive review of published research, we synthesized scientific information about the exposure and sensitivity of the grassland-shrubland ecosystem and grazing to climate change and the adaptive capacity of ranching operations. We present results that can help managers, climate service developers, and scientists better understand: (1) how this ecosystem is responding to current climate change, and is expected to respond in the future; (2) how changes in herbaceous forage composition, disturbance, and productivity impact rangeland livestock operations; (3) how current adaptation options, decision tools, and incentive programs may help stakeholders contend with future climate change impacts; and (4) what technical or socioeconomic barriers might make it more challenging for land managers to implement adaptation practices.

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Community science and environmental DNA for population monitoring

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Abstract

Global amphibian decline is a current conservation crisis. Monitoring amphibian populations is a critical conservation and management need. However, many amphibian species have low detectability in the field and funds for amphibian monitoring are extremely limited. We addressed both these concerns through the integration of community science and environmental DNA (eDNA). The Rocky Mountain Amphibian Program (RMAP) uses multiple independent surveys from agency field technicians and community scientists to monitor amphibian populations. The program has been highly successful; however, detection rates are insufficient for estimating trend for many species. Environmental DNA (eDNA), an innovative technique where species presence can be determined from DNA in the environment, can increase those detection rates. We collaborated with community scientists to collect eDNA to estimate amphibian presence. In summer of 2021, community scientists collected eDNA samples from 80 wetlands in 10 catchments paired with visual surveys. These same wetlands were surveyed by professional field crews. We will compare detection rates and error rates between the two surveyor types, as well as differences in detection rates for visual and eDNA surveys. We will end will best practices for successful eDNA community science projects and guidelines for implementation focusing on rangeland applications.

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Theory of seed mix design with applications to rangeland restoration

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Abstract

Returning desirable vegetation to degraded ecosystems is important for addressing ecological, environmental, and food security challenges of the 21st century. To explore the potential for using highly diverse seed mixes to prevent revegetation failures, we developed a theoretical framework that conceptualizes seed mix design in terms of simple rules and sets. This framework revealed universal truths about how plant densities change as more species and varieties are added to seed mixes. We applied our framework to data from seeding experiments in Montana and Colorado. This revealed that increasing numbers of species sown can appreciably reduce chances of both low and high plant densities. This reality could prompt practitioners to assume risks of species-poor seed mixes for the off chance of achieving high densities. We caution against this approach because low densities often lead to establishment failures whereas moderate and high densities tend to generate similar plant communities over the long term. Additionally, species-poor mixes generate lower biodiversity. Instead, all species that are compatible with management objectives should be sown, except for functionally redundant species with disproportionately expensive seed. Following this advice need not increase total seed costs. The idea is to decide on a total seed cost or rate and divide that cost or rate among as many species as possible. Moreover, the total rate should be divided evenly among the species, because this further reduces chances of low densities. These ideas extend to varieties in addition to species. Practitioners are often committed to sowing certain species but lack knowledge about which varieties of those species have the greatest survival rates. In these cases, all available varieties should be sown. The principles of seed mix design we advocate represent strong departures from current practice.

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Early calving benefits livestock production under winter and spring warming

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Abstract

In temperate rangelands, the timing of livestock breeding is managed so that most births occur late winter to mid-spring. Nutrient demands of young livestock increase steadily as they grow, while nutrients supplied by rangelands typically increase in spring then decline through summer as plant tissues mature and senesce. Timing births in late winter rather than spring can increase weight gain of young livestock by ensuring young are larger and in need of more nutrition when forage quality is greatest, but this risks exposing newborns to lethal cold. We studied effects of calving date on weight gain and exposure risk of beef calves using 82 years of data from the western U.S. Our analysis indicated that, averaged over study years, 180-d old calves weighed more (mean, 95% confidence interval) when born the beginning (early March) compared to the end (early May) of our studied calving interval. Early calving likewise appeared to benefit calf production (weight of 180-d old surviving calves per calf born), with benefits increasing as climate warming reduced neonatal mortality from cold exposure. Compared to calf production from early May calving, estimated calf production from early March calving was greater in the 1940s and greater in the 2010s. Continued late winter and early spring warming would further increase benefits of early calving.

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Labor Changes in Beef Production: A Social and Economic Investigation of Labor Market Shifts

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Abstract

Livestock producers depend on many systems working in harmony to produce an efficient and sustainable product. Producers must work to adapt to environmental factors such as drought, fire and floods, but they also have to adapt to technological factors included everything from equipment improvements and new vaccines, to virtual fences. The systems ranches and feedlots must balance are complex and dynamic – and in this balancing act, managers must make decisions about labor.

This presentation will share initial results of a study analyzing two decades of change in the labor market of the U.S. beef industry. This analysis reports results from a secondary data analysis of U.S. Agricultural Census Data on regional labor trends, and compares these results with anecdotal semi-structured producer interviews. We have identified three dominant topics from the data: (i) accounting for inflation, hired labor and contract labor expenses have increased across sectors and regions; (ii) in all but the southwest region, there has been a regional decrease (~ -20%) in hired ranch workers, yet hired labor expenses have increased by one third; and, (iii) feedlots present an interesting shift toward contract labor as opposed to hired workers- perhaps indicative of labor specialization in the feedlot industry. These trends in labor for the beef industry compound cyclical economic aspects for producer decision-making and keeping beef production operations sustainable.

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Rangeland Conversion Drivers and Impacts of Post-Conversion Management Strategies on Landscape Level Ecosystem Health

Fadzayi Mashiri, Laurent Ahiablame, Kofi Akamani, James Bartolome, Theresa Becchetti, Roger Duncan, Anthony Fulford, Phoebe Gordon, Peter Hopkinson, Kaveh Motamed and Gavin Stoddard.

There is widespread consensus that rangeland conversion impacts ecosystem services, but few studies have quantified the effects of conversion on multiple specific ecosystem function variable. In California rangeland conversion to cropland occurred in the Central Valley with over 20,000 acres converted to cropland every year between 1983 and 2008. In this multidisciplinary research, we investigate the socio-economic drivers of rangeland conversion and measure changes in multiple ecological variables when rangelands are converted to conventional or regenerative (organic with livestock integration) almond production systems. We measure whether ecological changes depended on the management of almond orchards. My presentation will cover the differences in plant diversity, insect diversity and two soil health variables between rangelands, and conventional and regenerative almond orchards. We collected soil cores to measure seedbank plant diversity; samples for soil health analysis, and pit and sticky traps for insect diversity from three (3) rangeland, and four (4) almond orchard sites. Half of the orchard sites were conventional, and half were regenerative. Each orchard system had two age cohorts of trees (younger <7 years and older >7 years). The effects of rangeland conversion on species diversity and soil health strongly depends on whether the almond system is regenerative or conventional. Regenerative orchards have similar or more plant and insect diversity than rangelands and always more than conventional. We found less SOM in young orchards under both systems compared to rangelands, which indicates loss of stable SOM when rangelands are tilled. Regenerative orchards have more species diversity and SOM than conventional. The potential benefits of regenerative production practices include higher water retention, biodiversity, ecosystem resilience compared to conventional systems. Armed with the understanding of the ecological impacts of rangeland conversion, and its drivers could help us develop more efficient mechanisms that promote sustainable and resilient rangeland systems and agriculture at landscape level.

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A Floral Survey of the Platte River Bluffs in Hamilton County Nebraska

Benjamin Janssen
University of Nebraska- Lincoln

Grasslands continue to be threatened throughout the United States by land conversion, invasive species, and woody encroachment. Due to the extensive loss of grasslands, preservation and restoration are key to the sustainability of these ecosystems. An integral part of preservation and restoration is determining existing diversity to measure success of preservation efforts and source seeds to be used in reconstruction efforts. Therefore, local plant diversity was assessed on five remnant prairies in the Nebraska Central Loess Hills using the Modified Whitaker sampling method. The two sites directly managed by a local conservation nonprofit returned the highest level of diversity in the largest plot size. Results also yielded unique species that currently have no county record for them in the relevant literature. Identifying floral diversity will prove valuable for future conservation efforts in central and eastern Nebraska. Future research should focus on assessing floral diversity on other remnant prairies, county level plant distribution, and the feasibility of creating landscape connectivity in the Nebraska Central Loess Hills.

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Title: Assessing plant community resilience to annual grass control in sagebrush steppe

Authors: Lisa C. Jones*, Georgia Harrison, Timothy S. Prather, University of Idaho, Moscow

Invasive annual grasses negatively impact sagebrush steppe by decreasing native plant diversity and shortening fire return intervals. Indaziflam, a longer residual herbicide, effectively controls annual grasses yet there is concern that such an herbicide can delay plant recruitment from the seed bank. Large-scale treatment that considers soil-surface droplet coverage was explored with indaziflam and indaziflam + imazapic (70 and 84 g/ha, respectively) applied aerially across a range of herbicide droplet coverage within a mountain big sagebrush (Artemisia tridentata ssp. vaseyana)-dominated pasture near Hailey, ID in fall 2019. We monitored vegetation composition annually for three years post-treatment. Three years post-treatment, herbicide applications controlled Bromus tectorum by 57-100% (mean 85%) compared to plots without herbicide. Treated plots averaged 6% cheatgrass cover compared to 41% cover in untreated plots. In 2022, perennial grass cover increased as herbicide droplet coverage increased; this effect was stronger for indaziflam than indaziflam + imazapic. Perennial forb cover on the other hand only differed by herbicide used: cover was greatest in indaziflam plots (mean 76%, sd 26%) compared to indaziflam + imazapic plots (mean 59%, sd 19), indicating imazapic's non-target impact on forbs, though cover values were still high. Three years post-treatment, we observed recruitment from the seedbank in the treated plots at the same level as in the untreated plots, indicating that herbicide application has not substantially impeded natural recruitment. We will continue to monitor plots to assess long-term annual grass control and plant community response.