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Climate & Drought

Shrub (*Prosopis velutina*) Recruitment in Sonoran Grasslands: Precipitation, Not Herbaceous Cover, Matters Most

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Abstract

Shrub recruitment is a critical first step in understanding the grassland-to-shrubland transformation process. Recruitment may vary with the timing, frequency, and amount of precipitation (PPT), with seed/seedling predator activities, and with grazing intensity. Here, we ask, "How do PPT, ant/rodent herbivory, and livestock grazing interact to influence velvet mesquite (*Prosopis velutina*) recruitment in Sonoran Desert grasslands?" An Automated Rainfall Manipulation System was used to manipulate PPT, wherein plots received -65% ambient PPT (= 'drought'), +65% ambient PPT (= 'wet'), and ambient PPT (n= 10/PPT treatment). Half of each plot was clipped to 15 cm simulating heavy grazing; the remaining half was unclipped. Exclusion treatments (None, Rodents, Ants, Rodents+Ants) were installed within each PPTxClipping combination. Scarified mesquite seeds were placed within each treatment combination at the start of the monsoon in July 2017, 2018, and 2019.

First year recruitment of the 2017-2019 seedling cohorts was consistently higher in wet and ambient conditions compared to drought, with the highest in 2017 (47 to 58% across PPTxClipping treatments), lowest in 2019 (6 to 10%), and intermediate in 2018 (1-22%) (χ^2= 277.8, p< 0.001). These interannual differences occurred despite all years having comparable rain days (2017= 30; 2018= 31; 2019= 33) and total monsoon season PPT (χ^2= 0.12, p= 0.94). However, the maximum number of consecutive rain days in 2017 (16 days totaling 153 mm) exceeded that in 2018 (9 days totaling 38 mm) and 2019 (6 days totaling 67 mm). Recruitment was reduced in areas accessible to rodents/ants in every year (χ^2= 46.1, p< 0.001). Contrary to expectations, grass defoliation had no effect in any year (χ^2= 0.05, p= 0.82). Our data suggest shrub recruitment in Sonoran grasslands is highly sensitive to intra-seasonal rainfall patterns, modestly sensitive to rodent/ant herbivory, and insensitive to herbaceous cover.

Effects of Climate Variability on the Dynamics of Rangeland Vegetation and Productivity in the Western US

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Abstract

Ranches in the western US rely on rangeland forage production for low cost feed to produce beef cattle. The threat of a changing climate and different degrees of drought will increase the variability of forage production on rangelands. To our knowledge, there is little research that couples observational data from satellite remote sensing to economic outcomes for individual livestock producers. In this study, we utilized Landsat-based plant productivity estimates to create a monthly forage production dataset from 1986 to 2018 on a 300-head, 21,000-acre ranch in central Idaho. Forage estimates were then used in simulations of a linear programming economic model that was parameterized for a representative 300-head cattle ranch to assess economic outcomes, such as income, expected herd size (culling, destocking), timing and intensity of grazing on land uses, and required supplemental feed production. To determine drought signals, we evaluated climate variables against forage estimates during the same time period. In addition, we ran three future scenarios including a normal, a drought, and an extreme drought scenario and modeled ranch outcomes 40 years into the future. To evaluate the economic model output, we ran linear regression models of income (dependent variable) against climate variables and forage production estimates (independent variables). We found that ranch income is sensitive to rangeland forage production and that drought (i.e., low precipitation, high temperatures and high vapor pressure deficits) leads to reduced economic viability of ranches in the western US. A better understanding of the impacts of climate variability on ranch income will lead to improved management decisions and increased ranch resiliency to future drought episodes.

Contrasting Outcomes of Winter and Summer Climate Change Forcing on Caribou Forage in Northern Alaska

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Abstract

The Arctic is rapidly warming with concomitant increases in precipitation during winter and summer and associated consequences for ecosystems. These changes are evident in a nearly Arctic-wide greening and expansion of shrubs but less apparent are changes in the plants themselves and the consequences for herbivores that rely on them for forage. In Arctic regions the most abundant large herbivore are caribou (*Rangifer tarandus*) which rely on summer forage to recover from winter deficits, and to build body reserves for reproduction during spring; any changes in forage quality can influence caribou fitness. We examine the impact of increased winter snowfall and warmer summer temperature, two forcings happening simultaneously, on tissue digestibility, leaf nitrogen (N) content, and protein precipitation capacity of tannins (PPC) in Arctic plants using experiments and observations. In a 20+ year snow fence experiment we observed higher leaf N content and digestible protein in deciduous shrubs such as *Salix pulchra* and *Betula nana* and graminoids such as *Carex spp*., and *Eriophorum spp*. under deeper snow but digestibility of forage was little changed. In *S. pulchra*, the higher leaf N extended the availability of high quality forage by over three weeks in the late summer. Under experimental warming using passive open-top chambers that raise air temperature ca. 1-2˚C we observed lower leaf N and digestible protein in *B. nana*., slightly higher leaf N in *Eriophorum spp*., but changes in digestibility were small. On warmer, south-facing hillslopes, we observed lower leaf N in five of six common species examined. Our results indicate that leaf N and PPC is more sensitive to climate forcings than digestibility, winter changes may be more consequential than summer, and any increase in forage N due to deeper winter snow may be partially offset by warmer summers.

Grass-Cast: An Experimental Grassland Productivity Forecast

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Abstract

Every spring, ranchers face the same difficult challenge—trying to guess how much grass will be available for livestock to graze during the upcoming growing season. Since May 2018, an innovative Grassland Productivity Forecast or "Grass-Cast" has been helping producers in the Great Plains reduce this economically important source of uncertainty. This experimental grassland forecast is the result of collaboration between the U.S. Department of Agriculture (USDA) Agricultural Research Service (ARS), Climate Hubs, and Natural Resources Conservation Service (NRCS); the National Drought Mitigation Center (NDMC); Colorado State University and the University of Arizona. Grass-Cast provides land managers with an indication of what productivity is likely to be in the upcoming growing season relative to their own county's history. Grass-Cast uses over 30 years of historical data on weather and vegetation growth—combined with remotely-sensed NDVI data and seasonal precipitation forecasts—to predict if rangelands in individual ~6 mile x 6 mile areas are likely to produce above-normal, near-normal, or below-normal amounts of vegetation. The program's accuracy improves as the growing season unfolds, so it should be consulted more than just once during the growing season. The maps are updated every two weeks to incorporate newly observed weather data and emerging trends in grazing conditions. This tool can help rangeland managers better anticipate drought and prepare for shortages in grazing resources while also providing a view of rangeland productivity in the broader region to help with larger-scale decision making, such as determining where grazing resources might be more plentiful if their own region is at risk from drought. Grass-Cast is currently available to producers in the Great Plains and the Southwest (NM and AZ) Regions of the U.S.

Quantification of the Ecological Resilience of Texas Drylands in Response to the Extreme Drought of 2011

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Abstract

Pastoralists generally use the worst drought conditions as a baseline for quantifying the economic and ecological impacts to and recovery of their vegetation resources. The degree, manner, and pace of recovery of vegetation productivity after a disturbance, such as fire and/or droughts, is called ecological resilience (ER). Areas of vegetation productivity that either increase or do not change in response to droughts exhibit the greatest ecological resilience and thus are the most critical resources to pastoralists during drought periods. The Texas drought of 2011 was the worst drought in the States' historical climatic record and led to the death of over 300 million trees at nearly 9 times greater than the background mortality rate. We have demonstrated in previous research that time series image differencing of vegetation index (VI) satellite imagery, where the VI image of the worst drought period is subtracted from every other image in the time series, can be used to quantify characteristics of a landscapes ecological resilience, including amplitude (the magnitude of the impact of a disturbance or the mean landscape conditions VI image minus the worst drought VI image) and damping (the magnitude of the difference of VI when the drought VI image is subtracted from each image in the time series). Consequently, we quantified amplitude and damping of a 1-km pixel resolution Moderate Resolution Imaging Spectroradiometer (MODIS) net primary productivity (NPP) time series of Texas Drylands from 2001 to 2019 in response to the 2011 NPP Texas drought. We found that the Basin and Range ecosystem or the Trans Pecos area of Texas by summation of the overlapping no change areas is the area that did not change in response to the 2011drought from 2001 to 2019.

Effects of Growing Season Aridity and Grazing Seasonality on Chihuahuan Desert Perennial Grass Production

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Abstract

With precipitation patterns projected to become more variable and temperatures predicted to increase over time, arid and semi-arid landscapes could become more arid which could cause a shift in the plant makeup of these valuable lands. The objective of this study was to investigate how growing season Aridity and season of cattle grazing influence perennial grass production in the northern Chihuahuan Desert. To explore aridity, temperature and precipitation, and season of grazing, we analyzed a 35 year-long (1967-2002) data set of perennial grass production in the Chihuahuan Desert that had been collected from pastures grazed in differing calendar seasons. We looked at perennial production of three dominant perennial grasses in this system: *Bouteloua eripoda*, *Aristida purpurea*, and *Sporobolus spp.* We found a strong relationship between total perennial grass and growing season (June-September) aridity wherein production decreased as aridity increased (R^2=0.6899). Compared to the continuously grazed, winter and spring grazed, or fall grazed, the summer grazed pasture generally yielded the lowest perennial grass production. After running a linear regression model, we found a strong relationship between perennial grass production with growing season aridity and grazing by seasonality of pasture (Yearlong pasture R^2=.7046, Summer Pasture R^2=0.3328). Looking at aridity on a temporal scale versus a spatial gradient showed how a dryland can be put through climate stress over time, especially in the face of grazing timing. Deciphering how timing of grazing and aridity impact perennial grass production in a desert grassland may offer new strategies for how to manage these valuable drylands. Considering roughly two-thirds of all global drylands are used for grazing, knowing how to utilize/adjust the timing of cattle grazing on desert grasslands is critical.

Drought Alters Soil Seed Bank Composition Within a Sagebrush Community: Decreasing Native Forb Seeds and Increasing Invasive Grass Seeds

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Abstract

The Western United States is projected to experience more extreme droughts due to predicted warmer temperatures and more variable precipitation. Yet the consequences of drought may not affect plant communities uniformly. The magnitude of change and types of species favored may differ among plant communities, even when exposed to similar abiotic stress. The soil seed bank can play a critical role in understanding how changes in abiotic conditions will affect semi-arid landscapes of the Western US, such as sagebrush steppe. There is little research on how soil seed banks will be altered due to climate change. But current research suggests that seed densities will decrease, particularly in open spaces where the soil becomes dryer with lower precipitation. Our study addressed the influence of drought and microsite (e.g. shrub and interspace) on soil seed bank composition within two sagebrush communities, one dominated by *Artemisia arbuscula* (little sagebrush), and the other dominated by *Artemisia cana* (silver sagebrush). We established drought manipulation plots that passively exclude approximately 40% of ambient precipitation. After 3 years of experimentally induced drought, we collected soil samples both beneath sagebrush canopies and within the adjacent interspaces in each community type, and quantified species richness and density in the seed bank using a greenhouse emergence study. We found that forb seed density was lower and invasive annual grass seed density was greater in the drought treatment compared to the control within the community dominated by *A. arbuscula*. In addition, shrub canopies provided a beneficial microclimate for forb seeds. Conversely, seed density within the *A. cana* dominated community was not affected by drought or microsite. Our results demonstrate that seedbanks of adjacent sagebrush communities with different dominant species may respond in distinct ways to drought and suggest that invasive annual grasses may increase at the expense of native forbs.

On the Right Side of the Hill: A Socioecological Analysis of Extreme Weather Events in the Nebraska Sandhills

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Abstract

Although the Nebraska Sandhills region is home to one of North America's largest, un-fragmented grassland habitats, groundwater-monitoring wells and weather stations are few and far between. Conversely, local ranchers and other small-scale data holders have quantitative and qualitative data that are rarely integrated into official monitoring programs. The purpose of this study is to explore the ways that local accounts of cold-season weather anomalies in the Sandhills can inform a comprehensive understanding of the role of climate variability on the social-ecological system.

Long-term residents with memories and/or records were interviewed in July 2020 for their insights into the effects of the 2018 and 2019 cold springs. Drawing from the descriptive and interpretive framework of the ethnography of communication, the interviews were analyzed in order to inform quantitative analyses. Temperature and precipitation data from a variety of sources were used to gauge the significance of these periods in relation to historical trends. While below-average temperatures and severe blizzards were widely experienced in both April 2018 and March 2019, the onset and consequences of each event varied in timing and quantity at the local and regional levels. Like the importance of traveling on "the right side of the hill" during a blizzard, timing and geography impact people and operations differently, even at a local level. These accounts highlighted the vulnerability to extreme weather phenomenon within the ranching community, exemplified by a rising water table, loss of hay grounds, and high cattle death loss.

This project used an innovative approach that is becoming more common in studies of environmental change—the integration of data collected from both biophysical and sociocultural systems. Such a socioecological focus, synthesizing first-hand, local accounts with satellite and in-situ scientific data, enhances understanding of the environment, hydrological systems, and the trajectory of change in the Nebraska Sandhills.

A Century of Weather Variability in a Texas Semi-Arid Rangeland: Effects on Management of Biotic and Abiotic Processes

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Abstract

Precipitation is the most important determinant of range conditions, and therefore has significant effects on all management practices such as grazing and prescribed fire. Studies suggest that less frequent but more intense precipitation events facilitate woody plant encroachment and result in state changes. We analyzed a continuous 100-yr precipitation dataset collected at the Texas A&M AgriLife Sonora Research Station near Sonora, Texas USA (30.6 N, 100.6 W, 610 mm annual precipitation). For further evaluation, we calculated the number of days with active precipitation and separated annual precipitation into meteorological seasons. Due to high interannual variability, there were no statistically significant trends apparent across the full time series. Trends became more apparent across shorter temporal scales: prior to the 1950s drought, variability was high. Following the 1950s drought, interannual variability lessened until the 1990s, when it began to increase. We also detected seasonal shifts in intensity and occurrence of precipitation events. We will translate these patterns into effects on forage biomass and quality that influenced range management practices including livestock grazing and prescribed fire.

Assessing Grazing Strategies to Cope with Multi-Year Drought in Northern Mixed Prairie

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Abstract

Droughts are likely to become more frequent, more intense, and of longer duration in the future. This will have substantial impacts on the functioning and service provisioning of rangelands. Land managers and ranch operators may use grazing strategies to ameliorate the impacts of multi-year droughts. To provide information about how grazing strategies alter the impacts of multi-year drought, we are conducting a multi-year experiment imposing various magnitudes of drought (ambient rainfall, 25%, 50%, 75%, and 99% rainfall exclusion) at two US northern mixed prairie rangelands (Thunder Basin Ecoregion near Bill, WY & Fort Keogh Livestock and Range Research Laboratory, Miles City, MT). Drought was imposed during the growing seasons (April-September) of 2019 and 2020. These drought treatments were crossed with three realistic grazing strategies that were developed using input from ranchers.

Drought treatments at both sites caused declines in soil moisture within experimental plots. At the Montana site, preliminary analyses showed a threshold effect of drought treatments on ANPP in year one (2019), where significant reductions of ANPP were only found under severe drought. However, in year two of the drought (2020), a steady decline in ANPP was found along the entire gradient of drought severity. Drought caused minimal ANPP responses at the Wyoming site, potentially due to an abnormally wet year in 2019 and an abnormally dry year in 2020. Yet despite these minimal effects on ANPP, we did find that severe droughts caused blue grama (*Bouteloua gracilis*) to senesce ca. 1-2 months earlier than ambient rainfall plots in 2019 and 2020. Here, we will also share our five-year research plan to assess how different grazing strategies alter the recovery of these lands after our imposed drought. Information from this study will enhance stakeholder ability to cope with increased frequency and severity of droughts throughout the 21st century.

Long-Term Declining Trends in Chihuahuan Desert Forage Production in Relation to Stocking Rates and Climate

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Abstract

We analyzed a 25-yr time series (1995 – 2019) of stocking rate (SR), ambient temperature, precipitation, and perennial grass production (PGP) at a 4000-ha site in the Chihuahuan Desert. Using the Proc Glimmix procedure in SAS 9.4, we analyzed effects of two SRs (light: 25-30% vs conservative: 31-40% forage use rate), year, and SR × year to evaluate time trends. Stocking rates had no effect on PGP (P = 0.25), but year did (P < 0.01). Stocking rate × year did not affect PGP (P = 0.94). We found a 75% reduction in in kg * ha^{-1} PGP when the first (115.4 ± 18.7 kg DM perennial grass) vs last three (28.27 ± 18.67 kg DM perennial grass) study years periods were compared (P < 0.01). Annual average ambient temperature during the 25-y study increased by more than 1°C (beginning: 15.22 ± 0.2 vs end: 16.7 ± 0.2°C). Mean maximum June temperature (P < 0.01; r = - 0.39) was negatively associated with PGP. Conversely, PGP was positively associated with total annual precipitation (P < 0.01; r = 0.28). The interaction of June mean maximum temperature and annual precipitation negatively affected PGP (P < 0.01). These preliminary results suggest that climate may have an overriding effect on Chihuahuan Desert forage production even when appropriate stocking rates are applied. Sustainability of beef production systems on southwest rangeland will increasingly be hampered by forage yields less than 100 lb*ac^{-1}; the point at which livestock grazing becomes financially unsound.

Practical Management Solutions for Changing Local Precipitation Patterns

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Abstract

Current climate change models predict little change in total precipitation received for Kern and Tulare Counties in California. Most models, however, predict less precipitation received as snow and more received as rain if temperatures continue to rise as predicted by models using moderate emission levels. This change is expected to affect crop producers more than livestock producers. Given current predictions, it's not clear what changes local livestock producers can expect looking forward. What are the implications for livestock producers facing an unclear future and how can they prepare? This presentation assesses local historic rainfall patterns over the past 60+ years for Kern and Tulare Counties and compares them with recent trends. Discussion will focus on emerging precipitation patterns and practical, effective mitigation strategies to sustain livestock production.

Ecosystem Restoration

Ways of Improvement of Degraded Pastures in the Foothill and Mountain Zone of the Shakhrisyab District

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Abstract

Within the framework of the UNDP-GEF Project "Sustainable Use of Natural Resources and Forestry in Key Mountain Regions Important for Globally Significant Biodiversity Species", during 2018-2020, the state and use of the pasture ecosystems of the Shakhrisyab District forestry is monitored.

Forest pastures are the territory of integration of the main types of natural resources - natural water and soil, various wild plant and animal species. Separate allotted areas of forest pastures can be used by humans for collecting medicinal herbs, as well as for seasonal grazing and haymaking.

In the structure of pastures of Uzbekistan, hayfields and pastures occupy 2.98 million hectares, of which mountainous - 4.3%, and alpine - 2.6%

The main threats to forest pastures:

- Reduction of habitats, decrease in the volume of water sources, as well as the number and reproduction of plant and animal species; - Increase in the area of degraded pastures; -Digression of pastures, deterioration of the state of biotic communities (ecosystems); - Reduced soil fertility, erosion and desiccation; - Aging of forests, decrease in biodiversity; -Illegal and haphazard felling of shrubs and trees;

To restore forest cenoses, it is recommended to re-seeding semi-shrub vegetation, such as *Ceratoides eversmanniana, Kochia prostrata, Artemisia,* grass species - *Onobrychus chorossanica, Poa bulbosa, Agropyron., Astragalus,* medicinal and resource species. Among the most important medicinal plants of the flora are *Crataegus turkestanicus, Ephedra equisetina, Ferula assa-foetida, Glycyrrhiza glabra, Hypericum perforatum, H. scabrum, Peganum garmala, Rosa canina, Ziziphora clinopodioides and Lagochilus inebrians* are very valuable medicinal plants.

In general, it should be noted that the resources of wild-growing medicinal plants are currently studied and developed completely insufficiently. In the future, the sustainable use of wild medicinal plants and their artificial breeding could become one of the important sectors of the economy and serve as a good source of income for the local population.

RestoreNet: An emerging restoration network reveals controls on seeding success across western drylands

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Abstract

Drylands are Earth's largest terrestrial biome, are widely utilized as working rangelands, and support one third of the global population. However, drylands are also highly vulnerable to land degradation. Despite widespread demand for dryland restoration and rehabilitation, little information is available to help land managers effectively reestablish native perennial vegetation across drylands. RestoreNet is an emerging dryland restoration network that systematically tests revegetation techniques across environmental gradients. Using the RestoreNet framework, we tested the effectiveness of restoration treatments (i.e., ConMod nurse plant structures, mulch, pits) that increase soil moisture and seed mixes with different climatic niches to achieve revegetation goals. Across sites, seedling recruitment was consistently influenced by treatment and seed mix type. Pit and mulch treatments increased total seedling density, with pits promoting the highest seeded species recruitment while limiting non-native plant establishment. Seeding increased total seedling density regardless of seed mix type, but cooler-adapted seed mixes promoted greater seeded species density and resulted in lower density of unseeded (non-native) species relative to warmer-adapted mixes. Seedling recruitment was also controlled by the temporal and environmental context of restoration with the positive effect of high precipitation greatest in the weeks immediately following seeding. Above-average precipitation during the study period across most of the sites may partially explain why the highest seeded species recruitment occurred in pit treatments and seed mixes with cooler, wetter niche requirements. Results from RestoreNet help to better understand variation in seeding and restoration treatment success across space and time in drylands. Relationships between restoration practices and environmental conditions in our study suggest the importance of anticipatory restoration strategies that forecast seasonal and sub-seasonal weather conditions and select plant species with niche requirements appropriate for current and future climate conditions. This information is critical to land managers tasked with improving ecosystem conditions across degraded dryland regions.

Plant and Soil Response to Irrigation, Fertilization, and Mowing on Agricultural Fields

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Abstract

Agriculture is an important contributor to British Columbia's economy, with nearly 349,000 hectares of land throughout the province being utilized to produce hay crops. With the growing concern of climate change, there is increasing pressure on the agricultural industry to change its management techniques to become more environmentally sustainable while still maintaining production of quality crop yields. We tested the effects of three agricultural management techniques; mowing, irrigation, and fertilization, on plant and soil characteristics to determine the best practices for managing land to be both productive and sustainable. We examined two enclosures that were constructed on an agricultural field used for hay production. One enclosure has been actively irrigated and annually fertilized for over twenty years while the second enclosure has not been actively irrigated or fertilized for the past eleven years. Within both enclosures, study plots have been subjected to different mowing heights, ranging from zero to thirty centimeters at five-centimeter intervals. Measures of plant production, forage quality, plant community dynamics, and soil chemical and physical properties were taken from all study plots within both enclosures. Preliminary results suggest that the highest amounts of plant production are produced by using lower mowing heights. Similarly, treatment plots in the irrigated, fertilized enclosure show higher amounts of plant production than the same treatments in the non-irrigated, non-fertilized study enclosure, indicating that these management techniques result in increased plant production. The results produced from this study will provide information on how irrigation, fertilization, and mowing can be utilized to achieve optimum plant production, soil health, and carbon sequestration, producing landscapes that are profitable to the environment and producers.

Finding the Sweet Spot for Control: Age and Growth Rate Relationships of Eastern Red Cedar (*Juniperus virginiana*) in Eastern South Dakota

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Abstract

Eastern red cedar (*Juniperus virginiana*) has encroached into grasslands throughout the United States and led to reduced grazing capacity and habitat suitability for grassland obligate species. Understanding the growth dynamics of eastern red cedar trees will help us to develop cost-effective management plans in the northern Great Plains. The objective of this study was to estimate and model the relationship of tree age and various growth parameters. In March 2020, we harvested forty eastern red cedar trees from a grassland site managed by the USFWS near Volga, South Dakota. Harvested trees were classified into one of five height classes (0-50, 50-100, 100-150, 150-200, and 200-250 cm). We measured tree height, canopy area, trunk basal diameter, and yearly basal growth for each specimen. We determined the age of each tree by counting annual rings from a thin trunk section under a microscope. In addition, we measured the width of the last four rings to estimate basal diameter growth rate. We built four age and growth rate models including tree height, basal diameter, canopy area, and basal growth rate. The best fit models for canopy area and basal growth rate are exponential models with an r^2 of 0.73 and 0.69, respectively. Tree height and basal diameter were best described by a linear relationship with an r^2 of 0.72 and 0.71, respectively. The results demonstrated that eastern red cedar trees increase in tree height and trunk basal diameter at a constant rate. However, tree canopy and basal growth rates grow at an exponential rate, with low canopy cover up to about 9 years old and then rapid increases in the following years. Due to this trend, early detection and management action should be taken to control eastern red cedar encroachment into prairies and grasslands of the United States and other countries.

Effects of Salt-Impacted Soil on Native Seed Imbibition and Germination

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Abstract

Approximately 900 million hectares worldwide are estimated to be salt-impacted, with 10.6 million hectares in the northern Great Plains (NGP). In the NGP, salt impaction results when salts in marine sediments move upward through the soil profile and remain near the soil surface after evaporation. Once salts accumulate to a high enough level, the ability of seeds to imbibe sufficient water to germinate can be lost. This study investigates the ability of fifteen native species to imbibe and germinate in saline conditions and thus may be suitable for remediation of salt-impacted areas. We also investigated the effect of mechanical scarification on imbibition and germination. Species were chosen via expert opinion, literature review, Natural Resources Conservation Service fact sheets, and a Northern Great Plains Herbaria search. Imbibition and germination experiments were conducted using two seed treatments (control and mechanically scarified) and four soil solutions (deionized water, and high, medium, and low salt) resulting in n = 1,024. Seeds were mechanically scarified using a Forsberg Seed Cleaning Machine and soil solutions were extracted from field-collected soil. Imbibition was calculated and germination was assessed from total germination, mean germination time, and mean germination rate. Scarification, soil solution, and their interaction significantly ($p < 0.05$) affected imbibition for *Asclepias syriaca*, *Panicum virgatum*, and *Spartina pectinata*, whereas only scarification and the interaction were significant for *Sporobolus airoides* and *Sphaeralcea coccinea*. Scarification, soil solution, and their interaction were significant for the total germination of *Solidago missouriensis* and *S. airoides*. Results from this study will provide information essential for the remediation of salt-impacted soils in the NGP using native plants.

Science-Management Information Gaps and Solutions for Surface Management of Oil and Gas in the Intermountain West

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Abstract

Successful reclamation of disturbed lands following oil and gas development can be challenging. Oil and gas development on US public lands is concentrated in the Intermountain West, much of which is managed by the Bureau of Land Management (BLM) and characterized by dry conditions, challenging soils, and heterogeneous landscapes. The objectives of the review described here are to determine the oil and gas surface management information needs of the BLM, review the available scientific literature to address these needs, and identify knowledge gaps that may limit effective management and successful reclamation. These objectives were addressed through: (1) a review of relevant BLM oil and gas planning documents; (2) conducting interviews with BLM staff who work in surface management of fluid minerals; and (3) a comprehensive literature review to identify peer-reviewed literature related to oil and gas management and policies. We structured our findings around standards for defining success, monitoring methods, and reclamation practices. In general, our document review and interviews revealed a high need in specific areas: (1) scientifically robust standards that can be applied across heterogeneous environments, (2) updated monitoring approaches that can quickly and consistently collect needed data, and (3) approaches for evaluating outcome trends across an entire oil field or landscape. We found a few examples of field offices with standards and innovative adaptive management, and significant scientific literature on monitoring that can be applied to oil and gas. Although the largest proportion of scientific literature was in the 'practices' topic area, interviews suggest there is still insufficient knowledge to reclaim sites that have challenging soils and dry climate conditions. We conclude by identifying specific synthesis and science needs, as well as describing new web tools the USGS is developing to help address some of the science and management information gaps addressed in our review.

Using Conservation Planning Software to Optimize Conifer Treatment in Sage-Grouse Habitat Within the Great Basin

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Abstract

The expansion and infill of pinyon (*Pinus monophyla*) and juniper (*Juniperus osteosperma*, *J. occidentalis*; hereafter conifer) woodlands threatens the imperiled sagebrush (*Artemisia spp*.) ecosystems of the Great Basin by degrading habitat for sagebrush obligates like the greater sage-grouse (*Centrocercus urophasianus*). Increased conifer cover reduces sage-grouse habitat use and sage-grouse that use these impacted areas have relatively higher mortality rates. Thus, conifer-impacted areas that remain dominated by sagebrush may act as ecological traps, as studies found negative impacts to sage-grouse occupying habitat with as little as 2.5% conifer cover. Therefore, managers require tractable, science-based tools to optimize the ecological and economic effectiveness of proposed efforts to remove conifers and restore sage-grouse habitats. Using a multi-stage modeling approach, we extended and improved a spatially-explicit conservation planning tool that targets conifer removal by quantifying restoration success as defined by the ecosystem's resilience to disturbance (i.e., degree of conifer cover) and resistance to invasion, as well as the effectiveness of treatment relative to sage-grouse habitat suitability. This tool: 1) simulates conifer removal within user-provided treatment polygons using a high resolution (1-m2) conifer map developed from object-based image analysis; 2) quantifies spatial variation in understory dynamics like sagebrush community type, dominance, and annual grass invasion to simulate recovery success and; 3) incorporates predicted surfaces derived from models of sage-grouse selection, use, and survival to calculate improvements in post-treatment habitat suitability. The tool is fully automated within a web-based application and provides a user-friendly interface. The outputs include pre- and post-treatment seasonal habitat suitability surfaces for sage-grouse and ranks proposed treatment sites by cost-effectiveness. This framework can be expanded to include other disturbances (e.g., wildfire) and active restoration scenarios (e.g., seeding and transplanting). Findings are preliminary and provided for timely best science.

Understory Vegetation Change Following Woodland Reduction Varies by Plant Community Type and Seeding Status: A Region-Wide Assessment of Ecological Benefits and Risks

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Abstract

Woodland encroachment is a global issue linked to diminished ecosystem services, prompting the need for restoration efforts. However, restoration outcomes can be highly variable, making it difficult to interpret the ecological benefits and risks associated with woodland-reduction treatments. We addressed this uncertainty by assessing the magnitude and direction of vegetation change over a 15-year period at 129 sagebrush (*Artemisia* spp.) sites following pinyon (*Pinus* spp.) and juniper (*Juniperus* spp.) (P–J) reduction. Pretreatment vegetation indicated strong negative relationships between P–J cover and the abundance of understory plants in most situations and all three components differed significantly among planned treatment types. Thus, to avoid confounding pretreatment vegetation and treatment type, we quantified overall treatment effects and tested whether distinct response patterns would be present among three dominant plant community types that vary in edaphic properties and occur within distinct temperature/precipitation regimes using meta-analysis (effect size = *lnRR* = ln[posttreatment cover/pretreatment cover]). We also quantified how restoration seedings contributed to overall changes in understory vegetation components. Meta-analyses indicated that while P–J reduction caused significant positive overall effects on all shrub and herbaceous components, responses were contingent on treatment- and plant community-type combinations. Restoration seedings also had strong positive effects on understory vegetation by augmenting changes in perennial grass and perennial forb components, which similarly varied by plant community type. Collectively, our results identified specific situations where broad-scale efforts to reverse woodland encroachment substantially met short-term management goals of restoring valuable ecosystem services, but also where P–J reduction disposed certain plant community types to ecological risks. Resource managers should carefully weigh these benefits and risks and incorporate additional, appropriate treatments and/or conservation measures for the unique preconditions of a given plant community in order to minimize exotic species responses and/or enhance desirable outcomes.

How You Chop Matters: Plant and Mule Deer Responses to Tree Removal by Three Methods

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Abstract

Land managers in western North America often remove pinyon and juniper trees, either to reduce fire risk, increase understory forage, improve wildlife habitat, or some combination of these reasons. Because prescribed fire is risky to implement, mechanical methods such as chaining, roller-chopping, and mastication are often used. These mechanical methods differ in their cost and in the size and depth of the woody debris produced and may also differ in how plants and animals respond to them. We implemented an experiment in December 2011 in the Piceance Basin in northwestern Colorado, USA, to compare these three mechanical methods (n=7). We assessed plants 1,2,5, and 6 years post-treatment, and mule deer response via GPS collars 2-8 years post-treatment. By 2016, treated plots had 3-5 times higher perennial grass cover and ~10 times higher cheatgrass cover than control plots. In 2013 and again in 2017, roller-chopped plots had higher cheatgrass cover than other treatment types. Roller-chopped plots also had the most bare ground 1-year post-treatment, and when seeded, had the highest density of desirable forage shrubs. Summer utilization of desirable shrubs in 2017 was higher in masticated plots than chained or roller-chopped plots, which were in turn higher than control plots. Winter mule deer point detections per individual were higher in chained and especially roller-chopped plots than control, while masticated plots were similar to control. Plant and mule deer responses varied by mechanical treatment type. Roller-chopped plots, which were the riskiest in terms of cheatgrass invasion but afforded the most opportunity for desirable shrub establishment, were most utilized by deer in winter.

Oil and Gas Reclamation on US Public Lands: How It Works and Improving the Process with Land Potential Concepts

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Abstract

There is an increasing worldwide concern for the current and long-term environmental impacts of oil and gas development such as severe habitat fragmentation, disruption of plant-water relationships, increased soil toxicity, and altered hydrology of landscapes. In response to this concern, U.S. federal land agencies are participating in innovative practices and research for decreasing the negative environmental effects of development. One of their primary areas of focus has been on public lands where the government is under a multiple use mandate to manage for all the ecosystem services a site has to offer. The multiple-use mandate of public land management has always been a challenge for federal agencies; compounded by policies and priorities varying with administration. This is especially true for oil and gas development and can set up a contentious environment for federal employees to practice, research, and regulate oil and gas development. Additionally, there is no national standard in the U.S. for how reclamation from oil and gas development should be conducted, and there is a lack of understanding for what constitutes successful reclamation. The concept of land potential (i.e., successional trajectory of a plant community) could be a foundation for reclamation monitoring and assessment. This talk will discuss how the implementation of land potential concepts in reclamation may enable adaptive management of oil and gas development across state lines and regulatory entities on public land in the U.S.

Restoring Arid and Semi-Arid Rangeland Soil Microbial Communities and Belowground Ecosystem Function: Surface Coal Mine Reclamation

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Abstract

One of the goals of surface coal mine reclamation is the reestablishment of an effective, diverse, and sustainable ecosystem suitable for post-mining land use per the Surface Mining Control and Reclamation Act of 1977 and implementing regulations. The post-mine land use in the southwestern United States is typically livestock grazing and wildlife habitat. The scope of this presentation focuses on restoring belowground ecological soil processes during the reclamation of surface coal mines in arid and semi-arid regions. Effective reclamation depends on the successful recognition and treatment of limiting factors. Recovery of the soil microbial community is beneficial to successful reclamation because of the important ecosystem functions facilitated by microorganisms. Soil microbial communities can be important for successful reclamation of rangeland ecosystems as post-mined soils typically exhibit low microbial diversity, biomass, and enzymatic activity initially. Topsoil stockpiling is known to have negative impacts on soil physical, chemical, and biotic properties including adverse effects on the soil microbial community. Topsoil materials require careful handling during removal, storage, and redistribution to preserve the existing microbial populations. Fungi have been shown to play a critical role in arid-soils, including efficient decomposition of recalcitrant C compounds, N-transformations such as nitrification, nutrient storage, and translocation of C and N between plants and biotic soil crusts. The soil microbial community is directly affected by mining disturbance due to the loss of soil organic carbon, changes in soil pH, compaction, and erosion. As a result, the biogeochemical cycles may also be severely impacted. Mine operators are encouraged to develop detailed time-tables and/or logistic models to achieve reclamation goals because of the relatively short time frame for re-establishing diverse, effective, and permanent plant communities. Future mine site reclamation protocols should consider preservation of native belowground microbiome diversity through appropriate topsoil handling and storage practices to maximize reclamation success.

Establishing Native C4 Tallgrasses on Degraded Rangeland in Central South Dakota

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Abstract

Many grasslands in the northern Great Plains have been invaded by exotic C3 grasses, including annual and perennial bromes (*Bromus spp*.), Kentucky bluegrass (*Poa pratensis*), and crested wheatgrass (*Agropyron cristatum*) after a century of use by domestic livestock. We attempted to restore native C4 tallgrasses and midgrasses to one such pasture in central South Dakota using 2 different stocking densities (~40,000 or ~200,000 pounds of cow/acre), 4 different herbicide treatments (No herbicide, spring glyphosate, December atrazine, or glyphosate + atrazine), and 3 seeding treatments (No seed; C4 native grass mix dominated by big bluestem at 6.2 lb. pure live seed (PLS)/acre; or C4 native grass mix at 7.4 lb. PLS/acre + 0.8 lb. PLS/acre native forbs). Seeding and herbicide application occurred in 2017. Grazing was short-duration (ranging from 2 hours to 3 days in a paddock) primarily in May, before C4 grasses had produced much growth. The experiment included 9 replicates with all combinations of treatments. The soil was a Lowry silt loam. Each experimental unit was 20 x 40 feet. Control of C3 exotic grasses was very successful. January to July precipitation was just 6.8 inches in 2017 and 7.2 inches in 2018, hindering establishment. Precipitation reached 8.4 inches from January to July in 2019. In 2019, we counted every seeded grass in the plots, excluding any seedlings that may have been present. Stocking density did not influence establishment success. Techniques including glyphosate (with or without atrazine) and seed (with or without forbs) resulted in ~1 target grass/yard^2. All other techniques failed to establish target species. Outside of the experimental area, where herbicides were not used, we observed a complete failure of establishment except in swales. This suggests that in these dry years, elimination of competition from invading species was necessary for establishment.

Utah Watershed Restoration Initiative Partnership

Tyler Thompson[1], Daniel Eddington[2], Alison Whittaker[2], Danny Summers[3]

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Abstract

The Utah Watershed Restoration Initiative (UWRI) is a partnership-based program, administered by the Utah Department of Natural Resources, which seeks to improve the functional capacity of high priority watersheds throughout the state. Since its inception in 2006, the UWRI partnership has completed nearly 2,300 projects to restore and rehabilitate over 2,000,000 acres in Utah watersheds. The UWRI program is unique to the west, in that it transcends jurisdictional boundaries, and local, state, and federal management authority to focus finite resources on completing high priority conservation projects. For additional information, please visit the website at https://watershed.utah.gov/

Promoting Rangeland Health in Southeastern British Columbia, Canada, Through Invasive Plant Control and the Re-Establishment of the Native Plant Community

Myra Juckers, Katherine Stewart

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Abstract

Rangelands are a critical system within southeastern British Columbia (BC), Canada, supporting biodiversity and wildlife habitat. As well, they have high cultural value, providing forage for livestock, food, and medicinal plants. However, rangeland degradation has promoted the establishment and spread of invasive plants, such as *Potentilla recta*, which is a growing concern. Management strategies to control invasive plants and re-establish native plant communities are necessary steps to aid in rangeland recovery and promote rangeland health. Over two growing seasons (2019 and 2020) targeted goat grazing (grazing once vs grazing twice per season) and herbicide application (single application of Milestone) were examined as management strategies to control *P. recta* on two sites near Cranbrook, BC. A greenhouse trial was also conducted to examine the effectiveness of a native plant community, seeded with and without fertilizer, in suppressing *P. recta* growth. Targeted grazing conducted twice per season, and herbicide application, led to a significant reduction in *P. recta* growth (biomass) and reproduction (number of seed heads). However, differences in the effects of grazing were observed between sites, suggesting site condition may influence grazing treatment effectiveness. In the greenhouse, both above and belowground *P. recta* biomass was significantly reduced when *P. recta* was grown with native forbs and grasses. Re-establishing healthy native plant communities, in addition to implementing strategies to directly control invasive plants, are important elements to manage invasive plants within rangelands and improve the health of this system.

The Land Treatment Exploration Tool: A Practical Resource for Managers Planning Rehabilitation and Restoration Actions

Michelle Jeffries, David Pilliod, Justin Welty

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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 and example cases of how the tool could be utilized.

Costs and Benefits of Pinyon-Juniper Removal for Public and Private Land Managers: A Case Study in Central Nevada

Egan Cornachione

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Abstract

This study uses data collected from two controlled pinyon-juniper (PJ) treatments on public and private lands in central Nevada to evaluate the costs and benefits of PJ removal. Starting from an ecosystem services framework based on ecological processes, I quantify the ecological responses to treatment and map them to their associated economic benefits. The results suggest that for a lop and scatter treatment on mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*) rangelands in central Nevada, treatment generates positive net economic and financial benefits. For public land managers, the net present value (NPV) of public economic benefits outweigh costs by a ratio of 7.8:1. For private land managers, the NPV of private financial benefits outweigh costs by about 1.5:1, while also generating similar public benefits. Much of the public benefits from treatment are due to reductions in future projected wildfire suppression costs by avoiding an eventual post-fire conversion to cheatgrass, while the private benefits are primarily from increased forage. Additional economic benefits identified include enhanced water availability, recreational use benefits, and sage grouse habitat protection. Sensitivity analyses were conducted to show that more expensive mastication treatments would generate a negative economic return, and administrative costs would reduce the benefit-cost ratios. This paper provides a simple reproducible framework for using cost-benefit analysis in aiding decision-making for PJ treatments. The results suggest that increasing landowners' access to capital and cost-sharing agreements between ranchers and public land managers may generate a win-win scenario for both public and private land managers in cases where treatment costs are sufficiently low. In cases where treatment costs are high as in mastication or chaining, the social and private benefits may not outweigh the costs of treatment.

Contemporary Techniques Used to Address Soil Compaction on Reclaimed Grasslands

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Abstract

Land degradation derived from energy production continues to expand globally. Subsequent traditional best-reclamation practices may provide satisfactory results aboveground, but poor conditions belowground (e.g. soil compaction) can persist for decades, degrading the ecological integrity of reclaimed landscapes. This prompts the need to investigate alterative reclamation practices to determine if current practices can be improved upon. The goal of this research is to compare traditional best-reclamation practices (control) to alternative-reclamation practices and assess their effect on alleviating soil compaction and promoting greater plant diversity. Treatments included deep ripping either at the subsoil or topsoil horizons, the integration of straw mulch into the subsoil horizon, and seeding to either a traditional native grass mix or a non-traditional native grass/forb mix. The control had no ripping, no mulch application, and was planted with the grass/forb seed mix. In year one, penetration resistance (PR) between treatments is highly variable with no consistent difference across treatments. By year three, the overall PR of all treatments and the control have increased, but now nearly all treatments at all depths are trending lower in PR relative to the control. Additionally, variability amongst treatments continues to decrease. The greatest sources of variation for the vegetation community comes from year, seeding method, and ripping. This research has the potential to provide mining companies cost effective alternative reclamation practices that could improve the ecological integrity of reclaimed lands.

Plant Community Dynamics on a Restored Fracking Pond

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Abstract

Prior to oil and gas extraction, it is commonly recommended that topsoil be stock-piled for future site restoration. Our goal is to quantitatively assess the use of stock-piled topsoil following soil disturbance in a semiarid region. Our study area, a retired fracking pond, was re-surfaced in 2017 with 5-yr old topsoil stock-piled prior to construction. We segregated the stock-pile into 3 layers (each 1-1.5 m thick) and distributed these layers in separate strips over the pond; an area not re-surfaced acted as a control. Each surface was divided into 15 subplots, each receiving one of three seeding treatments: (1) 13 native grasses, (2) 13 native grasses plus an annual warm-season grass cover crop, or (3) non-seeded. Plant community composition with respect to seeded species has been monitored for 3 years following restoration. We used permutational multivariate analysis of variance and correspondence analysis to analyze community compositional dynamics. Seeded species composition was affected both by surface layer and seeding treatment. Each of these effects, however, interacted with sampling date: non-seeded areas changed more slowly over time than seeded areas; and ordination suggests that composition was more variable in 2020 than in 2018, especially for top and bottom stockpile layers. These results will help determine the efficacy of the common recommendations of stock-piling topsoil and native grass seeding for grassland restoration at our site in south Texas.

Fire on Rangelands

Using Targeted Grazing to Mitigate Wildfire Risk by Reducing Fine Fuel Loads in British Columbia's Wildland/Urban Interface

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Abstract

During recent fire seasons the value of grazing was evident in changing fire behaviour by helping slow, turn, or stop fires from moving across the landscape. The British Columbia Cattlemen's Association has partnered with the Province of British Columbia to develop a pilot program with the intent to decrease wildfire risk in BC's wildland/urban interface by reducing fine fuel loads/breaking up fine fuel continuity through targeted grazing while maintaining ecological and multiple use values.

Four sites were established in 2020, two in the Okanagan region, and two in the East Kootenays.

The project includes several monitoring components to assess the impact of grazing on fine fuel load, plant communities, and ecological function. Monitoring is composed of two components **intensive** and **extensive** monitoring.

Intensive monitoring occurs after grazing on small, randomly sampled areas. Sites will be stratified, and intensive sampling will occur in a subset of the area. Seventeen primary variables were assessed, including plant community composition, biomass, conifer regeneration, etc.

Extensive monitoring is intended to have broader coverage of the pilot site and can provide alerts to unanticipated benefits and problems of targeted grazing, performed every two weeks during grazing. The key monitoring element is level of grazing use assessed by stubble height. Results are communicated to project managers every two weeks.

Preliminary data comparing grazed and non-grazed controls shows that the targeted grazing treatment was not successful in meeting fuel mitigation objectives (a lack of difference in total biomass, but significant differences in forb biomass). Grass heights show only 15.2% use of grass species in grazed vs. non-grazed controls. Cattle manure and ungulate pellet group analysis reflects wildlife vs. livestock use on these study sites, and data related to ungulate grazing use was obtained on one intensively monitored site that did not receive livestock grazing pressure in 2020.

Cattle Grazing Reduces Fine Fuels and Wildfire Intensity in California Rangelands

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Abstract

The widespread and severe wildfires in California during the past several years highlight the importance of understanding how land management practices such as cattle grazing affect wildfire risk. We evaluated how much fine fuel (grasses and other plants) are eaten by cattle on rangelands, and how this may affect wildfire behavior. These results have not yet been published, but preliminary results are presented. We found that about 1.8 million beef cattle grazed California's rangelands, which include grasslands, oak woodlands, and shrublands, in 2017. Our analysis showed that cattle consumed vegetation across about 19.4 million acres of non-federal rangelands. The amount of fuel consumed per acre varied greatly based on region. The average amount of fuel removed across grazed rangelands in the state was 596 pounds per acre. Maintaining flame lengths below four feet is often cited as a critical threshold that allows fire fighters to safely access an area from the ground without heavy equipment. Fire behavior models developed for this study suggest that maintaining grassland fine fuels at or below 1200-1300 pounds per acre during spring and summer will keep flame lengths below four feet at wind speeds up to 40 mph, but lower fuel loads may be required during extremely dry conditions. These numbers are useful for interpreting the impacts of reducing fuel levels, but they still need to be experimentally validated in California. Cattle grazing plays an important role in reducing fine fuels on grazed rangelands in California. Without grazing we would have hundreds to thousands of additional of pounds/acre of fine fuels on the landscape, potentially leading to larger and more severe fires. There are opportunities to improve fire safety in California by strategically grazing rangelands with high biomass that are not currently being grazed, or by increasing grazing intensity on very lightly grazed areas.

The Effects of Grass Invasion and Fire Severity on *Acacia koa* Regeneration

Natalia Hamilton, Nathan Gill

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Abstract

With invasive grass increasing wildfire occurrence worldwide, there is a need for bettering our understanding of grass-fire cycles and their effects. Hawaii's 2018 Keauhou Ranch Fire presents an opportunity to study interactions between invasive grasses, native plants, and wildfire. We investigated grass cover's interactions with burn severity and native *Acacia koa* recovery. Our three questions: 1) At what level of precision can grass cover be accurately (≥60% accuracy) estimated from oblique aerial photos? 2) How are post-fire *A. koa* regeneration densities affected by fire severity? 3) How are *A. koa* regeneration densities affected by grass cover and its interaction with fire severity? We hypothesized we would be able to accurately estimate grass cover using four levels of precision, that areas with higher fire severity would have less post-fire *A. koa* regeneration, and that post-fire *A. koa* regeneration would be lower in areas where high pre-fire grass cover interacted with high severity fire. We collected data from 30 transects across three land cover types (woodland, montane woodland, and montane shrubland). We estimated pre-fire grass cover from oblique aerial imagery taken in 2014 and evaluated those estimates with in-situ data from 60 unburned transects of the same cover types. We measured burn severity (percent mortality, scorch height, char height) and post-fire grass cover at the burned transects. Grass cover estimate accuracy was 67% in montane woodland, 100% in shrublands, but only 20% in woodlands. Although accuracy of pre-fire grass cover estimates in shrublands were high, variance in that cover type was low, with grass cover never exceeding 24%. Within montane woodland, post-fire *A. koa* regeneration densities were higher with increased fire severity when pre-fire tree densities were low. *A. koa* regeneration density was not affected by pre-fire grass cover nor its interaction with fire severity.

Wildfire Negatively Impacts Greater Sage-Grouse: A Before-After-Control-Impact-Paired-Series Assessment

Emmy Tyrrell[1], Peter Coates[1], Brian Prochazka[2], Shawn Espinosa[3], Joshua Hull[4]

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Abstract

Contemporary sagebrush (Artemisia spp.) ecosystems within the Great Basin are increasingly threatened by self-perpetuating invasive annual grass-wildfire cycles. The conversion of sagebrush to exotic grassland following wildfire jeopardizes the persistence of greater sage-grouse (Centrocercus urophasianus; hereafter sage-grouse), a sagebrush obligate of high conservation concern that require large tracts of structurally and functionally diverse sagebrush communities. While long-term adverse effects of wildfire on sage-grouse abundance within the Great Basin have been reported previously, scientific information on demographic responses of sage-grouse to wildfire is limited. The few studies that address demographic rates often lacked appropriate controls that consider pre-wildfire spatial heterogeneity, an inherent property in most ecological systems. Two independent wildfire events at a study area located in northwestern Nevada and northeastern California provided a unique opportunity to investigate the effects of wildfire on sage-grouse demography. We carried out a before-after-control-impact-paired-series (BACIPS) study design using 10 years of sage-grouse telemetry to estimate nest and adult survival, which are the most influential vital rates for population growth in this species. We then developed a stage-based, stochastic population growth model that integrated our estimated parameters from wildfire impacts to understand cumulative impacts to overall rate of change in population abundance. Our results suggest wildfire has both an immediate and strong impact to key life stages of this sagebrush indicator species. Findings are preliminary and provided for timely best science.

Fuel Break Effectiveness Linked to Accessibility, Environmental Conditions, and Treatment Type in a Retrospective Assessment of Wildfires Across the Western U.S.

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Abstract

Accelerated cycles of wildfire and annual grass invasion are threatening iconic sagebrush ecosystems of the American West and the species that inhabit them. Wildfire management is at the core of conservation plans for the sagebrush ecosystem, especially critical habitat for species of conservation concern such as the greater sage-grouse (*Centrocercus urophasianus*; hereafter sage-grouse). Fuel breaks are a key component of wildfire suppression and may minimize catastrophic losses of sagebrush (*Artemisia spp.*) by disrupting fuel continuity, reducing hazardous fuel loads, and facilitating fire suppression operations, but an extensive evaluation of effectiveness at broad spatiotemporal scales is lacking. We compiled a comprehensive database of fuel breaks across 12 western states and intersected them with wildfire perimeters from the Monitoring Trends in Burn Severity and GeoMAC databases from 1984–2018 (fire events; n = 1532). We coupled fuel break fire events with environmental data characterizing topography, fuels, fuel break condition and accessibility, and weather in a retrospective analysis to identify conditions related to fuel break effectiveness using a Bayesian modeling framework. We found that fuel breaks with greater contact with fire and those impacted by larger fires were less likely to be successful. In addition, we identified variation in the effectiveness of fuel break treatments based on the ecosystem's ability to resist annual grass invasion and recover from wildfire (i.e., resilience). We also found that fuel continuity and fuel break accessibility influenced success. Specifically, greater continuity of fine fuels decreased probability of fuel break success whereas fuel breaks closer to roads were more likely to be successful. These results can help managers identify areas for fuel break installations and manage tradeoffs between fire suppression and sagebrush disturbance, such as habitat fragmentation caused by fuel breaks. Findings are preliminary and provided for timely best science.

Monitoring the Effects of Fire on Plant Communities and Wildlife Use in the Southern Great Plains

John McQuaig, Sam Fuhlendorf, Craig Davis, Laura Goodman

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Abstract

The majority of plant communities in the Southern Great Plains have been shaped by fire and are adapted to this form of periodic disturbance. Likewise, the wildlife in this region have also evolved with fire as a prominent ecological process. Fire can promote heterogeneity and enhance wildlife diversity when implemented to create a shifting mosaic of habitat types. Many managers acknowledge that fire is an important management tool but may not fully understand the post-fire effects on the plants and animals they are managing. This study examined the response of different fire-adapted plant communities to prescribed fire at 3 Wildlife Management Areas in Oklahoma. At least nine, 1-acre plots were sampled at each site to compare how each plant community responded over time to fire and season of burn. Camera traps were placed on select plots to monitor wildlife use of the fire treatments. Our results indicated that fire-adapted plant communities may temporarily change in structure due to a fire event but remain mostly unaffected at a larger temporal scale. Therefore, we concluded that to properly manage these plant communities for structural heterogeneity, prescribed fire must be implemented. Results also gave us strong indication that most wildlife species either have a neutral or positive response to burning, regardless of the burn season. This study addresses many of the challenges associated with studies involving prescribed fire, time-since-fire, and photo capture data.

Sage-Grouse Response to Wildfire: Analyses of Range-Wide Effects and Relationships Between Sage-Grouse Demography and Underlying Post-Fire Sagebrush Recovery Processes

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Abstract

Wildfire has long-term adverse impacts on greater sage-grouse (*Centrocercus urophasianus*; hereafter sage-grouse) population persistence throughout the Great Basin. However, chronic effects of wildfire may vary at broad spatial scales based on climate and ecological properties related to the ability for sagebrush (*Artemisia spp.*) ecosystems to recover and resist conversion to invasive annual grass. These properties drive variation in sagebrush recovery after disturbance and are expected to influence changes in sage-grouse population abundance. We extended on previous methods of modeling sage-grouse population rate of increase (λ) in the Great Basin to a range-wide study extent and developed an advanced sagebrush recovery model using back-in-time classification of satellite imagery in burned areas over the past 34 years. Specifically, we employed a preliminary variable reduction step followed by analysis of important covariates in state-space models within a Bayesian framework. After accounting for density dependence using a Gompertz model structure, we found evidence in a lag effect for precipitation and other weather related covariates within drier and warmer areas. Importantly, the proportion of burned areas within 5–10 km of leks negatively impacted population growth but positive influence of precipitation was negated by long-term impacts of wildfire, although this effect varied among regions. This study represents the first effort to investigate variation in broad-scale impacts of wildfire to sage grouse. Findings are preliminary and provided for timely best science.

Effects of fire energy on resprouting vigor of Honey Mesquite (*Prosopis glandulosa*)

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Abstract

The ability to resprout from protected buds is a survival trait exhibited by many woody plants that occur in disturbance-prone environments. Thus, encroachment of resprouters into rangelands once dominated by grasses can lead to regime shifts that are difficult to reverse. Honey mesquite (*Prosopis glandulosa*) encroachment into rangelands in the Southern Great Plains is especially problematic due to mesquite's prolific ability to resprout following disturbance. Recent research has suggested that "extreme" fire (performed under exceptionally hot and dry conditions) may reduce subsequent stem densities of resprouters. However, the impact of extreme fire on mesquite resprouting capacity has not yet been investigated. We monitored resprouting behavior of 48 individual mesquite trees exposed to different levels of fire treatment (high-energy and low-energy) and root crown exposure (root crown exposed vs undisturbed). Focal trees were burned individually within 100 m^2 plots from July 30 – August 6, 2018 near Sonora, Texas (30.6 N, 100.6 W, 610 mm annual precipitation). Focal tree status (resprouting vs not resprouting) and total number of resprouts (basal and epicormic) were assessed in 2019 and 2020. Trees exposed to low-energy fire were 99.9 times more likely to have live resprouts in 2020 than those exposed to high-energy fire. Fire treatment, root crown exposure, wind, and relative humidity were significant predictors of number of epicormic resprouts in 2020. Trees treated with low-energy fires had 541 times the number of epicormic resprouts than high-energy treatments. Root crown exposure was a significant predictor of number of basal resprouts in 2020. Basal resprouts on trees with exposed root crowns were 44% lower than intact crowns in 2020. Our results suggest high-energy fires are more effective at reducing the probability of resprouting and the number of epicormic resprouts. The potential for restoration of mesquite-encroached rangelands through multiple high-energy fires should be investigated.

Patch-Burn Grazing Extends Flower Availability and Synchrony in Rangelands

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Abstract

The status of grassland pollinators is closely tied to the diversity and availability of floral resources. However, planting a diverse complement of wildflowers to ensure that a species is flowering throughout the growing season may be prohibitively expensive. Reinstating native disturbance regimes across landscapes may extend the phenological diversity of existing flower species by creating heterogeneity. In this study, we investigated the effects of patch-burn grazing on floral resource diversity and availability. Experimental treatments included season-long grazing in the absence of fire (SLG), season-long grazing with dormant-season burns using a four-year fire return interval (PBG1), and season-long grazing with a combination of dormant-season and growing-season burns using a four-year fire return interval (PBG2). We conducted weekly flower counts across treatments from 15 May to 1 September 2018 and 2019. The data was used to assess differences in plant diversity and total flowering time between treatments. Floral richness was similar among treatments during the early growing season; however, the treatments diverged later in the growing season with the patch-burn units having over twice the number of species as the SLG treatment. The PBG1 and PBG2 treatments had an overall 2.1 and 2.6 times more ramets as the SLG treatment during peak growing season, respectively. Floral richness followed the same trend, with 1.3 and 1.5 times more plant species in PBG1 and PBG2; respectively, compared to SLG. These trends became more pronounced over the course of the season. Preliminary results suggest that patch-burn grazing can increase the amount, diversity, and stability of pollinator resources, potentially benefitting declining pollinator species by providing consistent resources through time and space.

Lone Star Tick (*Amblyomma americanum*) Response to Vegetative Changes Wrought by Season of Prescribed Fire in a Semi-Arid Savanna Ecosystem

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Abstract

Lone star ticks (*Amblyomma americanum*) pose a significant economic threat to livestock production as well as to human health. Lone star ticks (LST) attach and take blood from vertebrate hosts as larvae, nymphs and adults with significant portions of their life cycle spent off-host in vegetative habitats between each host. It is common practice to treat livestock with acaricide periodically to reduce tick numbers on infested animals, but treatments fail to reduce LST populations that are sustained by a wide range of wildlife hosts. Prescribed fire has been reported to reduce LST populations in some ecosystems by altering the micro-habitat necessary for off-host tick survival, but its efficacy has not been evaluated in semi-arid regions. We evaluated LST response to fires performed in different seasons (summer, winter, no burn) in a long-term (>25yr) livestock exclosure on semi-arid rangeland near Sonora, Texas USA (30.6 N, 100.6 W, 610 mm annual precipitation). We trapped ticks using CO2 traps placed under mottes and within interstitial zones in each burn treatment. We analyzed counts using negative binomial regression. Traps in interstitial spaces captured fewer ticks than did mottes in all three treatments. Areas treated with prescribed fire had fewer ticks than unburned areas, with stronger impacts from summer fires than winter fires. Our results suggest that habitat changes caused by repeated prescribed fires in semi-arid regions impact LST populations. Our experiment should be replicated at scales relevant to host movements to evaluate the interaction between hosts and tick mobility.

Mismatches in Prescribed Fire Awareness and Implementation in Oklahoma, USA

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Abstract

Anthropogenic modification of land in the Great Plains region of the U.S.A. has caused loss of biodiversity and detrimental impacts on ecosystem services. One of these modifications is alteration of historical fire regimes in the Oklahoma. Prescribed fire is an important land management practice for restoring ecological processes in altered landscapes. Most of Oklahoma's land is privately owned, thus the use of prescribed fire would require the participation of land owners to apply the practice throughout the state. In order to gauge the support for prescribed fire among the residents of Oklahoma, we included questions in an ongoing, statewide survey that asked about support for, and where applicable, utilization of the practice. In 2016, we used the M-SISNet survey to ask three questions of all 2,547 participants, with additional questions contingent on a respective respondent's residential setting in rural or suburban and urban settings. Greater than 90% of participants, stated support for the prescribed fire as a land management practice. The amount of support was the similar whether rural or suburban/urban. While suburban and urban responses expressed support for prescribed fire, those respondents' residential settings excluded use of the practice. Among rural respondents, those who live in areas where prescribed fire could be applicable, while support was high, a much smaller portion of these participants, < 26%, stated that they actually used the practice. Explanations supplied by these respondents for not using prescribed fire were dominated by lack of training, lack of equipment, and choosing not to burn. The first two reason given could be addressed by trained professionals providing training and by outreach by and expansion of prescribed burn associations (PBA), groups of local of stakeholders organized with the intention of increasing the proper use of prescribed fire.

Effects of Pyric-Herbivory on Plant Community Dynamics in the Northern Mixed-grass Prairie

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Abstract

Fire and grazing are disturbances that interacted with each other to shape grasslands for millennia, creating mosaic landscapes with highly diverse plant communities. Present Land management has removed fire from this ecosystem, creating homogenous landscapes that are dominated by invasive grass species, such as Kentucky bluegrass (*Poa pratensis*) and smooth brome (*Bromus inermis*). To determine if reintroduction of the fire-grazing interaction (pyric-herbivory) could promote more heterogeneous and diverse plant communities, we evaluated the differences in plant community composition and diversity between a continuous grazing treatment and two patch-burn grazing treatments. Despite differences in management history, we found no differences in plant community composition prior to implementation of treatments between the block of pastures being used in the continuous grazing treatment and those being used in the patch-burning treatments. We determined average plant community composition between the continuous grazing treatment and the patch-burn grazing treatments were different ($P<0.05$) and became increasingly different with time using non-metric multidimensional scaling (NMDS) and permutational multivariate analysis of variance (perMANOVA). We also found the patch-burn grazing treatments had higher diversity indices ($P<0.05$) than the continuous grazing treatment in all treatment years, with a difference of 40% at the end of treatment. This increase in diversity can be beneficial to plant communities, as high diversity plant communities have been found to be more resilient to drought and produce higher quality forage for livestock. These more diverse plant communities can also positively influence the diversity of higher trophic levels such as pollinators. Therefore, patch-burn grazing should be considered as a tool for conservation of grasslands and possibly as a replacement for conventional season-long livestock grazing.

Shifting Savanna Stability: Assessing Semi-Arid Grassland Dynamics via Experimental Manipulations of Fire Disturbance and Non-Native Herbivore Impacts

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Abstract

Semi-arid grasslands are transitioning away from grass-tree codominance to shrub-dominated woodlands. The structural and functional integrity of these ecosystems are at risk due to the effects of climate change and mismanagement including fire suppression and livestock overgrazing. Prescribed fire is necessary to conserve and restore semi-arid grasslands but herbivore pressure in these systems can reinforce positive feedbacks that prevent desirable alternative state changes and further promote woody encroachment. We assessed the effects of mammalian herbivores, including non-native and native deer, on plant productivity and community composition after prescribed fire events of varied fire energy (kJ/m^2) on the western Edwards Plateau in Texas. Whole plot fire energy treatments (low, high, none) were randomly assigned to 72 100m^2 plots. Subplot herbivory exclosures (0.5m diameter, 1.5m tall) and uncaged control treatments were replicated within each whole plot. Fire energy treatments were kept consistent by adding a continuous coverage of hay (60kg) to the low energy fire plots while the high energy fire plots received 60kg of hay as well as 200kg of juniper foliage and branches. We predicted that low energy fire treatments with exclusion cages were likely to enhance grass vegetation production and herbaceous plant cover while high energy fire and no herbivore exclusion would show the largest decrease on productivity. Herbaceous cover increased in low fire/exclusion plots from 24 ± 6 g/m^2 one year post-fire to 54 ± 5 g/m^2 two years post-fire. Grass cover increased from 23 ± 7 g/m^2 to 89 ± 5 g/m^2 and forb cover decreased from 25 ± 5 g/m^2 to 11 ± 4 g/m^2. High fire/no exclusion plots had significantly less above ground vegetation biomass than any caged treatments at all sampling times ($p < 0.0001$). A more data-driven, empirical understanding of fire and herbivore presence as ecosystem drivers is essential for future conservation and management of threatened semi-arid ecosystems.

Gulf Cordgrass Community Vegetation Response to a 3-Year Fire Return Interval of Winter and Summer Prescribed Burning

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Abstract

Prescribed burning is one of the tools widely used for habitat management. It simulates a natural process that eliminates old growth and sets back vegetative succession, promoting native flora that benefits both livestock and wildlife species. Vegetation response depends on several factors such as, phenological stage, soil moisture content and the plant's natural response to defoliation like fire. South Texas is known for frequent periods of drought and a long growing season, therefore, making it difficult to decide when to apply prescribed burning. We are beginning the second phase of a patch-burn grazing study comparing two seasons of prescribed burning (winter and summer) that was focused on the plant community dynamics and forage production of Gulf cordgrass (*Spartina spartinae* [Trin.] Merr. ex Hitchc.). Results of the first phase showed no differences between winter and summer burning in forage production and plant functional group composition for the first three months following burning. For the second phase, we returned fire to previously burned patches while keeping season constant. Treatments of short and long-term fire return intervals (3 and 5 years, respectively) were randomly assigned and combined to winter and summer treatments. We monitored vegetation growth and plant composition in no-burn and winter and summer burn patches. Vegetation sampling occurred before burning and at approximately three months following each burn, and at every late spring and fall. Our objective is to compare fire return intervals to analyze plant community dynamics in the Gulf Prairies and Marshes Ecoregion. We will include preliminary results that compare winter and summer prescribed burning at the 3-year fire return interval by analyzing plant functional group and forage standing crop.

Small Mammal Community Responses to Fire and Grazing in the Northern Mixed-Grass Prairie

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Abstract

Landscape heterogeneity is essential for ecosystem biodiversity. Historically, the interaction of fire and grazing, known as pyric-herbivory, created heterogeneity in the Great Plains capable of supporting a wide variety of wildlife and diverse small mammal communities. Present land management creates homogenous landscapes and habitat due to a lack of disturbances that vary spatial, temporal, and in intensity for creating a wide array of habitat types, which has led to a decrease in biodiversity of rangelands. To determine how small mammal communities would react to reintroducing pyric-herbivory, we evaluated the differences in small mammal communities in a conventional continuous grazing treatment and two burn grazing treatments. Each treatment was replicated four times, with eight sampling sites per replication for a total of 32 sampling sites per treatment. Sampling in the patch-burn grazing treatments occurred in both burned and unburned patches. We sampled sites over 2 consecutive nights and concurrently in each treatment replicate in June of each year, from 2017-2020. Total species abundance was highest in patch-burn grazing treatments. Deer mice (*Peromyscus maniculatus*) had the highest abundance of any species across treatments, but was highest in patch-burn grazing treatments. Vole species (*Microtus spp.*) abundance decreased with time in the patch-burn grazing treatments, while remaining stable in the continuous grazing treatment. Species richness was highest in the patch-burn grazing treatments (S=8) and lowest in the continuous grazing treatment (S=5) over the course of the study. Higher total species abundance and richness in patch-burn grazing treatments can most likely be attributed to the shifting mosaic landscape produced by the rotation of annual fires and focal grazing creating more variable habitat structure needed for various species. This suggests that patch-burn grazing could be used to create heterogeneous landscapes of variable habitat structure needed to support various small mammal species and increase small mammal abundance.

Contrasts in Vegetation Mineral Content with Patch-Burn Grazing

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Abstract

Patch-burn grazing is a livestock management practice that provides a wide range of benefits to ecosystem conservation and livestock production. Mineral nutrition is important for livestock health and performance; however, the impact fire has on mineral content of vegetation in the northern Great Plains remains unknown. In this study, we determine how burning affects the mineral content of available vegetation through the growing season. Data were collected on mixed-grass rangeland at Central Grasslands Research Extension Center in south-central North Dakota during 2017 and 2018. We clipped vegetation in recently burned patches and unburned patches on thin loamy ecological sites at the same sampling locations in spring and late summer. We dried samples for 72 hours at a temperature of 105^{o} C, and then ground with a Willey mill using a 1-mm screen. We analyzed all samples for calcium, phosphorus, copper and zinc content. All minerals were significantly greater in the burned than unburned patches. Copper, phosphorus and zinc were significantly greater in burned patches compared to unburned patches at the beginning and end of the growing season. Calcium had similar content in burned and unburned patches during spring, but was significantly greater in burned patches by late summer. Increased mineral content in vegetation on burned areas has the potential to reduce mineral supplementation costs and increase cow performance through enhanced immune functioning and reproductive performance.

Grazed Ecosystems

Harvest and Grazing Efficiency of Forage Grazed by Cattle on the Grand Staircase Escalante National Monument

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Abstract

Harvest and grazing efficiency have been used to refine stocking rates on rangelands throughout the North American Great Plains. The harvest efficiency coefficients developed on these rangelands show that a 25% harvest efficiency coefficient is needed to obtain 50% utilization under a moderate stocking rate. However, there is little information on harvest efficiency estimates on other rangeland types, especially arid landscapes that are dominated by bunch-grasses and shrubs. The purpose of this research was to quantify harvest and grazing efficiency coefficients for the Grand Staircase Escalante National Monument. In order to calculate harvest and grazing efficiency, utilization, and forage intake by cattle were calculated. We found that harvest and grazing efficiency differs across the landscape due to the heterogeneous nature of the rangeland. Because of this, it may not be appropriate to refine stocking rates using harvest and grazing efficiency in the way it is has been used in other rangeland and pasture settings that are more homogenous in nature.

Investigating the Effects of Different Harvesting Intensities on Forage Production in Sahand Rangelands of Eastern Azerbaijan Province, Iran

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Abstract

Due to the decreasing trend of rangelands, many native species are vulnerable and even at risk of extinction. Therefore, seed preservation and propagation of native species of rangelands and recognition of the characteristics of grazing, drought tolerance and their production potential are very beneficial. In this study, the five species of *Festuca ovina*, *Festuca rubra*, *Bromus tomentellus*, *Alopecurus textilis* and *Thymus kotschyanus*, which are the key species of Sahand Rangelands in Eastern Azerbaijan province, were studied. Treatments in each block included four grazing intensities, namely 25%, 50%, 75% and the control (no harvesting). The harvest was performed during the growing season and at the beginning of the grazing season for four years (2007-2010). Results of statistical analysis showed that the effect of harvesting intensity, year and intensity by year interaction were significant for forage production of *F. rubra*, *B. tomentellus* and *A. textilis* ($p<0.01$). However, the effect of year and intensity for *T. kotschyanus* and the effect of year for *F. ovina* were not significant. Results showed that forage production of species was different in years. Higher forage production in 75% harvest intensity was obtained in *B. tomentellus*, *F. rubra* and *A. textilis* with average values of 15.8, 18.1 and 16.7 g/p, respectively. In latter species, forage production was much affected by climate changes rather than the harvest intensity. The highest forage production of *F. ovina* was obtained in light harvest. Increasing the harvest intensity may decline plant vitality. It was recommended that allowable grazing intensity of Sahand rangeland might be 25% up to 50% harvesting intensity for preserving these species.

Collaborative Adaptive Rangeland Management, Multi-paddock Rotational Grazing, and the Story of the Regrazed Grass Plant

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Abstract

Frequent, severe defoliation reduces grass production, particularly for grazing-sensitive species. Multi-paddock rotational grazing has long been proposed as a grazing strategy that may be able to reduce the frequency and intensity of defoliation on palatable grass plants without altering stocking rates. Previous studies evaluated this hypothesis using small, homogeneous paddocks and non-adaptive rotation schedules, and found small and inconsistent differences between continuous and rotational grazing systems. Using a stakeholder-driven Collaborative Adaptive Management (CAM) framework, we conducted the first ranch-scale experimental investigation into tiller defoliation dynamics in the context of adaptive multi-paddock rotational grazing. We monitored tiller defoliation frequency and intensity in twenty paired 130-ha pastures which were assigned to either a collaborative adaptive multi-paddock rotational grazing treatment (CARM) or a season-long continuous grazing treatment (TRM) at the same stocking rate in shortgrass steppe. Consistent with previous studies, we observed that frequencies of grazing and regrazing on a palatable, cool-season grass (western wheatgrass, *Pascopyrum smithii*) were much more sensitive to stocking rate than grazing system treatment. Under the moderate stocking rates used in both CARM and TRM treatments, roughly two-thirds of western wheatgrass tillers remained ungrazed annually, regardless of grazing system. Thus, season-long rest is present in season-long continuous grazing as well as rotational systems. Levels of regrazing in CARM and TRM were low (5-15%) and similar between treatments. We conclude that the use of adaptive multi-paddock rotational grazing should not be expected to enhance the production or abundance of this palatable, cool-season species. Although defoliation dynamics were similar between CARM and TRM at the whole ranch scale, CARM enhanced spatial and temporal heterogeneity in defoliation frequencies among individual pastures. This higher and predictable variation could provide management flexibility. The CAM model enabled us to identify and directly address key stakeholder hypotheses, and enhanced stakeholder ownership and trust of research results.

Livestock and Prairie Dog Impact on Plant Community Production and Composition Across Three Ecological Sites

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Abstract

Prairie dog occupation of rangelands is often seen as a detriment to beef production because of reduced forage quantity. Within northern mixed-grass prairie, prairie dog colonies are often converted to low growing perennial grasses intermixed with patches dominated by annual forbs. However, it is unclear what impact combined cattle and prairie dog grazing has on plant communities across ecological sites. We conducted a 5-year study in a northern mixed-grass prairie near McLaughlin, South Dakota to determine the impacts of cattle and prairie dogs on plant community production and composition across three ecological sites (ES). Twenty-five paired sample sites on- and off-colony were established and randomly assigned to be fenced to exclude livestock or remain open to livestock grazing, creating four grazing treatments: two in off-town locations (non-graze (NG) and cattle only graze (CG)) and two in on-town locations (cattle and prairie dog graze (CPD), and prairie dog only graze (PD)). Within each sample site three 0.25m^2 permanent plots were randomly located. Plots were sampled in early August of each year to estimate biomass by species. A mixed model ANOVA was used to test for differences in standing crop biomass and percent biomass for C3 grasses, C4 grasses, and forbs between treatments and ES. There was a significant difference ($P < 0.05$) in total biomass between all grazing treatments and ecological sites but no interactions. On-town sites tended to be characterized by a reduction in C3 graminoid biomass and an increase in C4 graminoid and forb biomass compared to off-town. The PD treatment had 37% less biomass than the CG treatment, potentially due to increased level of herbivory and replacement of C3 mid-grasses with C4 shortgrasses. Results of this study indicate that herbivory, specifically presence or absence of prairie dogs, is a primary driver in plant community production and composition.

Sustainable Cattle Ranching as a Woody Encroachment Management Tool in the Temperate Savannas of the Southern Cone of South America

Diana Restrepo

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Abstract

Invasive woody species are a problem for ranchers in Uruguayan grassland ecosystems. Agricultural producers were interviewed to determine their receptivity to various forms of woody plant control, and to determine which control methods were most appropriate for the local regulatory and cultural context. We used historical imagery to examine the expansion of forestry plantations west of the properties under study in the Colonia Juan Gutiérrez. In this paper, we also provided a detailed land cover account of the three major areas of interest, the forestry plantations, the Rincon de Perez conservation area, and the properties of the participants in our study, which are situated in the floodplain of the Queguay Grande River. We interviewed nine producers who participate in the Alianza del Pastizal and therefore are familiar with the Alianza's practices, and in some cases, implement them in their properties. These interviews indicated discomfort and sometimes outright opposition to some of the practices presented. At the same time, the interviews showed producers' receptivity to practices that support an approach to woody encroachment management where, instead of aiming for eradication, producers aim for coexistence. Although this approach seems controversial, some producers in this Colonia are already using this management approach to woody encroachment.

Testing Management-Intensive Cattle Grazing as a Restoration Tool in Semi-Arid Rangelands

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Abstract

Invasive species pose a significant threat to the livelihood of British Columbia (BC) ranchers. Spotted knapweed (*Centaurea maculosa*), in particular, can reduce native plant diversity, form dense monocultures and overwhelm the native seed bank. Locally relevant, innovative rangeland management strategies are needed to suppress weeds and enhance ecological function and productivity as a whole. Recent research suggests that short-duration, light to moderate grazing maximizes forage growth and quality while increasing plant biodiversity. Additionally, residual biomass post-grazing is an important source of organic matter that encourages long-term soil carbon storage. Our primary research objective was to test management-intensive grazing (MiG), extensive grazing, and targeted grazing practices for their ability to improve biotic and abiotic site characteristics, including a) soil carbon sequestration; b) plant community diversity, c) plant productivity, d) forage nutritive values, and e) the control of *C. maculosa*. Electric fence enclosures were established in *C. maculosa*-dominated rangeland in Merritt, BC. Cattle numbers and timing were controlled such that MiG was ten cow/calf pairs for one day at the end of the growing season, extensive was one cow/calf pair for ten days at the end of the growing season, and targeted was ten cow/calf pairs for one day at the height of spotted knapweed flowering. Preliminary findings support the use of targeted cattle grazing to control *C. maculosa*. Cattle readily consumed *C. maculosa* at the late bud-flowering stage; targeted grazing reduced the number of *C. maculosa* buds and flowers by 78% and 89%, respectively. *C. maculosa* provides cattle with adequate, nutritional forage when grazed at the late bud-flowering stage. Research results will generate targeted cattle grazing protocols for *C. maculosa* control, and we will assess whether intensive grazing practices can create productive invasive-free rangelands in BC's Southern Interior.

Why Do Western U.S. Rangeland Managers Continue to Struggle with Reducing Wild Horse Populations?

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Abstract

Public rangeland managers face mounting pressure to resolve increasing wild horse populations in the western United States, whose escalated ecological impact has alarmed numerous stakeholders. Current policy aims to reduce the population to be in balance with the appropriate management level (AML, the estimated public land carrying capacity for wild horses). Unfortunately, sustainable long-term solutions have remained elusive as current curtailment methods provide only limited, short-term success. Managers have been hamstrung due to frequent legislative changes dictating the range and scope of legal methods available to use. Such changes have in part been influenced by special interest groups seeking to conserve these populations. Current methods to reduce animal numbers are limited to relocation into confinement, adoption of eligible animals into the private sector, and sterilization to reduce population fertility. These strategies have had limited success due to extreme costs (confinement), constraints on the number of animals any one person can adopt, and low efficiency of fertility treatments given follow-up (costly) vaccination requirements, all of which are significant burdens on federal budgets (e.g., confinement costs now constitute >50% of the BLM's wild horse budget). To better understand the underlying factors contributing to wild horse population growth, a dynamic systems model was constructed in Vensim™, linking the population with today's curtailment strategies. Assuming the horse slaughter ban, fertility control rates, and confinement capacity do not change, the adoption rate needed to balance animal units with current AML would need to average 400 animals per month (or ≈4800 annually, a 57% increase compared to 2012-2019 adoption rates). Further tests elucidate the effectiveness of a combination of control strategies. Research into long-term fertility control and coalition building to renew prioritization of ecosystem health and amend constraints on animal sale and euthanasia requires creativity and compromise amongst stakeholders yet to be explored.

Recovery of the Herbaceous Component of Sagebrush Steppe Unimpeded by 75 Years of Moderate Cattle Grazing

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Abstract

Understanding the effects of contemporary cattle grazing on herbaceous perennial communities in big sagebrush steppe is important for managing for wildlife habitat, plant diversity, and productivity, yet potentially complicated by legacy impacts of historic livestock grazing. Here we evaluate whether recovery of herbaceous communities in eastern Oregon after the cessation of intense spring sheep grazing (1935) was affected by moderate cattle grazing in paired plots with or without grazing over the past 75 years (1936-2011). We tested for the effects of cattle grazing on herbaceous community change over time in plant density and composition as measured by Bray-Curtis dissimilarity. We also included current and prior to sampling year precipitation and a random term for pasture location. We further tested whether time since cessation of intense sheep grazing and moderate cattle grazing were associated with convergence or divergence in community composition as indicated by evenness, richness, species relative abundance (rank order), and turnover or species appearance or disappearance.

We found that total perennial herbaceous, forb, and grass density increased over time with or without cattle grazing, though species responses to cattle grazing varied from positive to negative. Community composition converged over time based on increasing evenness, decreasing Bray-Curtis dissimilarity, decreasing shifts in species relative abundance (rank order), and lower rates of species turnover (gain and loss). In contrast, contemporary cattle grazing was generally not associated with compositional change. Current or prior water year precipitation only occasionally affected herbaceous density and community composition. Our results indicate that sites with or without moderate long-term cattle grazing followed similar recovery trajectories in response to cessation of intense sheep grazing. Management planning and resource assessment focused on herbaceous perennial communities in sagebrush steppe should seek to separate the impacts of historic from contemporary livestock grazing practices.

Replicating Grazing Modeling Experiments: Challenges and Opportunities for New Insights

Benjamin Turner

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Abstract

Grazing management involves numerous interrelated, dynamic feedback linkages driven by a variety of environmental forcing (climate and inherent soil resources) and endogenous processes (plant-soil-animal feedbacks involved in nutrient capture and cycling). Outcomes of these processes have significant impacts on livestock grazing due to regulation of forage production, diversity, and quality. Systems modeling experiments over several decades has aided in the analysis and prediction of these dynamics and helped fill knowledge gaps by overcoming limitations of reductionist field experiments. Such efforts have relied on a) empirical relationships of precipitation and plant production; and b) coupling these estimates to assumed coefficients about range condition and previous rainfall trends; in order to c) model forage supply usable for grazing through changes in range condition, mostly irrespective of changes in plant community composition. Unfortunately, the high volume of data needed to parameterize and calibrate these models poses major challenges to extending and broadening them for greater impact (e.g., proactive examination of emerging grazing problems; customization for education and outreach efforts). Adopting a process-based mechanistic rather than empirical perspective alleviates this issue in part and provides scientists a much more flexible and adaptable core model structure capable of application to diverse ecosystem, climate, or management contexts. Here, we replicate a previously developed dynamic grazing model [Diaz-Solis et al. 2006. Use of irrigated pastures in semi-arid grazing lands: a dynamic model for stocking rate decisions. Agricultural Systems 88:316-331] that simulates livestock gains and dry standing crop over the period of 1 yr. We then modify core model structures to allow for a wider range of experimental designs (particularly for time-scales >1 yr.) and illustrate additional insights not recognized in the original formulation. We conclude with suggestions for future simulation experiments useful for long-term grazing management studies.

Texas Wintergrass Physiological Responses to Targeted Grazing and Microsite Location

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Abstract

In the Rolling Plains and other land resource areas of Texas and Oklahoma, Texas wintergrass (*Nassella leucotricha*; TXWG), a native, cool-season perennial bunchgrass is often affiliated with honey mesquite (*Prosopis glandulosa*) canopies, forming the mesquite/TXWG association. Typically, in dense stands of mesquite, TXWG is dominant in the subcanopy and mixed with C_4-grasses in the interspaces between trees. TXWG initially establishes under mesquite canopies, then spreads to interspace areas as mesquite density increases. In a study established near Vernon, TX, USA, we evaluated effects of grazing and microsite on TXWG physiology. Grazing treatments included: 1) a single, short-duration targeted grazing event (37,000 kg ha^{-1}), 2) repeated short-duration targeted grazing events, and 3) ungrazed control. In each treatment we monitored individual TXWG plants in one of two microsite locations relative to mesquite canopies: 1) interspace plants were located ≥ 2 m from mesquite trunks, while 2) subcanopy plants were located < 0.3 m from mesquite trunks. Leaf water potential and gas exchange measurements were taken on TXWG individuals in March, April, and May of 2018 and 2019. Rainfall totaled 65 mm in March to May 2018 and 125 mm over the same period in 2019. In both years, soil moisture in the top 5 cm was slightly greater in interspace than subcanopy microsites. TXWG in interspace microsites tended to have greater leaf gas exchange rates and specific leaf area (g cm^{-2}). However, at soil moisture levels below 12%, TXWG gas exchange was similar between the two microsites. Increases in gas exchange rates indicated that grazed TXWG were better able to capitalize on increases in soil moisture than ungrazed TXWG. Physiological data help explain TXWG resistance to targeted grazing and the persistence of the mesquite/TXWG association.

Arizona Extension Rangeland Monitoring Programs

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Abstract

Throughout Arizona, Cooperative Extension has been involved in rangeland monitoring as part of a collaboration with the Bureau of Land Management (BLM) and U.S. Forest Service (USFS) since 2000. These programs assist agency staff and ranchers in collecting long-term vegetation trend data that can be used for adaptive range management or during the grazing permit renewal process. An evaluation of these cooperative monitoring programs was conducted to determine the value ranchers and agency staff saw in the programs. Overall Extension monitoring programs are viewed as key sources of reliable data. Monitoring was viewed as essential in order to maintain grazing permits on public lands.

Quantifying Growing-Season Competition Between Prairie Dogs and Cattle in Shortgrass Steppe

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Abstract

In the North American Great Plains, black-tailed prairie dogs (*Cynomys ludovicianus*) are widely viewed as competitors with livestock but are also important for rangeland biodiversity conservation. Understanding when and to what extent black-tailed prairie dogs affect livestock performance can provide a basis to assess costs and benefits of prairie dog management. We studied the growing-season grazing distribution and weight gains of yearling steers in areas with versus without annual control of prairie dogs via rodenticides. In areas without prairie dog control, their abundance fluctuated dramatically due to epizootic plague outbreaks, from < 3% occupancy in 2008, to a maximum of 68% occupancy during 2013 – 2015, and back to < 5% during 2014 – 2017. Under most conditions, steers did not graze preferentially on versus off colonies. However, in a highly productive year that followed a prior wet year, cattle preferentially grazed on colonies. Conversely, during an extended period of summer forage senescence, cattle grazed preferentially off colonies. This is consistent with the hypothesis that prairie dogs should enhance cattle gains in wet years but suppress gains in dry years. However, analyses of weight gain over a 12-year period found that prairie dog effects did not vary interannually with variation in forage production. Rather, increasing prairie dog occupancy was inversely related to cattle weight gain across all years, where daily weight gain declined by 8% as occupancy increased from 0 to 60% of a pasture. Interannual variation in weather affected cattle performance to a much greater degree than prairie dogs, with gains declining 24% as growing-season precipitation declined from 240 mm (near-average) to 120 mm (drought). Our findings provide confirmatory evidence that prairie dogs compete with cattle during the growing season in shortgrass rangeland, but these effects were substantially smaller than expected based on the degree of forage suppression by prairie dogs.

Grazing for Biodiversity in Central California: Hands-On and Scientific-Based Range Management

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Abstract

Globally, native grasslands are being lost at a staggering pace mainly due to transformations caused by industrial agriculture and other human-productive activities. Most of the remaining grassland ecosystems are within working landscapes where livestock production is both common and widespread. In California, grasslands have been dramatically altered due to overgrazing and the introduction of invasive plant species. Grasslands with more than 10% native grass cover are deemed in good conservation condition.

The Santa Lucia Conservancy is a land trust managing 18,000 acres in Carmel, CA. Of this, 5,000 acres are grasslands that largely include a strong native component reaching well above the 10% conservation threshold. Grazing, which occurs on roughly 2,000 acres, began to more effectively combat the intertwined threats of overgrowth, oxidation, thatch accumulation, brush encroachment, and invasive species while simultaneously promoting native flora and fauna.

Our grazing program uses a resource-based approach to dictate herd movements--we plan in consideration of monitored species, forage levels, presence of ponds and riparian areas, erosion threats, and fuel management. The grazing rotation has flexibility built-in as these ecological factors determine the locations and boundaries of temporary fences. For seven years we have implemented a floristic monitoring program composed of 27 fixed exclosures — using ungrazed exclosures and adjacent grazed sample points, we have collected species-specific data to analyze grazing's effects upon the landscape. To help quantify the impact of our program, we have built a strong academic partnership with the USDA-ARS, and we expect to finalize our analysis in Spring 2021.

To date, our preliminary monitoring results show that our grazing program is reducing noxious weed density, increasing native vegetation diversity, and improving the habitat for endangered native vertebrates.

777 Bison Ranch South Dakota Excellence in Range Management Award Winner 2019

Matt Odden[1], Jessica Michalski[2]

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Abstract

The 777 Bison Ranch has been in the Hillenbrand family for over 40 years and has been raising bison for over 30 years. The ranch is located in western SD near Fariburn on the short and mid-grass prairie. The ranch has been practicing holistic management and rotational grazing for many years and raises 100% grass-fed cow/calf bison. They have a vast knowledge of grass species and grazing management. The diversity, vigor, and productivity of the ranch's native plant communities is at the heart of the management of the bison herd. The ranch does quick moves, often everyone to three days. They have a large number of pastures and utilize temporary electric fence to improve management from year to year.

A Preliminary Evaluation of Beef Water Footprint Values on Long-Term Light, Medium, and Heavy Grazed Rangeland

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Abstract

Identifying water footprint levels in beef cattle systems (**WF_B**) at an individual operational level is essential to improve cattle production sustainability. Estimating the human water-use for cow-calf, stocker, and feedlot phases indicate potential improvements toward lowering the WF_B. According to Rotz et al.'s (2019) national assessment of the United States, cattle in the Northern Plains have the second-highest blue water consumption levels (averaging 1,508 L carcass weight^{-1}). This study and others (Atzori et al., 2016, Menendez and Tedeschi 2020) suggest improvements be made at the individual operation level. Therefore, there is a critical need to assess the WF_B of rangeland systems at an individual management level for each supply chain phase. Without such evaluation, decreasing the WF_B on rangeland is likely to remain challenging. Two specific aims were identified for this study: 1) Evaluating the differences of rangeland plant communities' evapotranspiration (**ET**) rates on light, medium, and heavy grazing practices and 2) estimating water footprint values of beef cattle from range operations that are exported or remain in the Northern Great Plains for finishing. Assessment of ET rates and water footprint values were conducted in Western South Dakota using the recently developed dynamic Texas Beef Water Footprint Model (**TXWFB**; Menendez and Tedeschi, 2020). We parameterized the model with climate data and adjusted ET crop coefficients (ET K_c) for light, medium, and heavily grazed pastures. Simulations include beef finished in Western and Eastern South Dakota and Nebraska or were exported to Kansas to assess differences in WF_B values. A sensitivity analysis was performed to determine the variability of each scenario across the supply chain. Evaluation of ET K_c and supply chain water footprint values are likely to support individual producer actions toward water-efficient systems, classify the impacts of grazing strategies, and enhance communication across the beef supply chain.

Monitoring Sandhills Rangelands: Evaluating Difference in Plant Community Dynamics Across Ranch Management Strategies

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Abstract

The Sandhills Rangeland Monitoring Cooperative (SRMC) is a collaborative project that collects and evaluates monitoring data on a growing number of ranches in the Nebraska Sandhills. Although monitoring is important to ensure that management practices have desired results, livestock producers may often skip this step because of time constraints, difficulty in collecting data, and/or lack of useful interpretation of monitoring data. This project seeks to answer: 1) how producer-engaged rangeland monitoring data can best be used within an adaptive management framework to help producers determine effective management practices, and 2) how current management practices influence Nebraska Sandhills plant communities and soil health. The SRMC began collecting data on seven ranches in 2019 and grew to nine ranches in 2020. The cooperative ranches reflect diverse management styles from season-long grazing in large pastures to short-duration grazing in small pastures with high stock density. On each ranch, three to four study pastures were selected, within which three study sites were established on upland Sands ecological sites. Cover, frequency of occurrence, dry weight rank, and soil health data were collected at each site each year. Preliminary results suggest variability within and across ranches and potential regional differences in plant communities. Using principal components analysis, approximately 51% of the variability in plant species composition across the ranches was attributed to regional differences in the locations of the ranches. This paper will discuss the connection between management strategies, plant communities, and multiple soil health indicators in ranches in the Nebraska Sandhills.

Photosynthetic pigment content of *Artemisia diffusa i*n response to different grazing intensities in rangelands of Uzbekistan

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Abstract

In Uzbekistan, *Artemisia*-dominated rangelands cover 15 million ha representing 65% of the total rangeland area. At present, due to the extensive development of livestock husbandry and human pressure, *Artemisia* ecosystems are facing an increasing anthropogenic strain. Understanding the ecophysiological responses of these complex rangelands under various disturbance regimes is key for developing appropriate restoration measures. This research project investigated pigment concentration changes (chlorophyll a and b, carotenoids) of *Artemisia diffusa* Krasch. ex Poljak. in response to different levels of grazing intensity (light and heavy) for two widespread rangeland types (sandy and gypseous) in Uzbekistan.

Preliminary results suggested that photosynthetic pigment content of *A. diffusa* was significantly higher in heavily grazed rangelands compared to lightly grazed areas. In areas with high grazing intensity, pigment concentrations of Chl a, Chl b, and carotene were 0.78 mg/l, 0.37 mg/l, and 1.40 mg/l, respectively. Whereas, in rangelands with light grazing intensity pigment concentrations of Chl a, Chl b, and carotene were 0.33 mg/l, 0.14 mg/l, 0.92 mg/l, respectively. In both grazing intensity treatments, pigment rate differed with soil conditions, and was higher in gypseous soils than in sandy soils. On average, pigment content of *A. diffusa* was higher by 40% in gypseous soils compared to sandy soils in both light and heavy grazing treatments. The only exception was higher Cl a levels (0.88 mg/l) in sandy compared to gypseous soils (0.59 mg/l) on heavily grazed treatment areas. Results suggest that *A. diffusa* has higher photosynthetic capacity on heavily grazed rangelands. Such physiological behavior may indicate the existence of a high self-regeneration potential and a natural seed source for degraded rangelands. Further studies are needed to advance our understanding of the potential for *A. diffusa* self-regeneration on Uzbekistan rangelands.

Testing a Management Strategy that is Affordable, Effective, and Results in Profits and Improved Ecology

George Lindemann

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Abstract

At Coal Creek Farm in Eastern Tennessee, we're trying to demonstrate a management strategy that is affordable, effective, and results in profits and improved ecology. We're using cattle and controlled burns—two tools available to most farmers—to do it. Our farm was clear cut when we bought it. Angus are picky about their forage. Longhorns don't seem to mind going for the native grasses that grow after a burn. We wondered if burn/graze could be managed for reliability. If so, we might be able to raise cattle more affordably, restore (native wildlife-friendly) grasses, and, just maybe, increase profitability.

After two years of burns, we selected a 60-acre parcel where native grasses were emerging. We fenced in the area and introduced a herd of thirty Longhorn cow/calf pairs. The only cost was the effort required to burn the area twice and fencing, which is required to keep cattle anyway. The big question was, how long would the longhorns last in the enclosure before running out of food? If the longhorns could forage for a month or so on burned warm-season grasses, the experiment would be deemed a success. The herd spent most of April and May in the native area with no need to fertilize, lime, over-seed, or bush hog.

Burned thickets do indeed provide foraging for cows. While these areas cannot replace all cool season, maintained grass fields, there is a role for this type of ecology in the life cycle of a Cumberland Plateau Farm, and perhaps, farms elsewhere.

Watching my cows eat free native food in the company of newly returning native animals is my idea of farmer heaven. Our first burn/graze experiment has encouraged us to fence more burned thickets and expand our burning program.

Invasive Species

Simultaneous prediction and mapping of 30m multiple exotic grass species percent cover over Western U.S. rangelands.

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Abstract

Exotic species can have long-term effects in any ecosystem. However, invasion of exotic grass species in arid/semi-arid western U.S rangelands not only impact conservation and weed control but persist because of altered wildfire regimes. Key exotic annual grass species like cheatgrass (*Bromus tectorum*) and medusahead (*Taeniatherum caput-medusae*) can be highly problematic for land managers. We have developed and publicly released exotic annual grasses percent cover maps with various spatial and temporal resolutions in the western U.S. since 2015. Now we are testing a method to develop exotic annual grass percent cover maps concurrently for individual species for a larger western U.S. rangeland ecosystem that covers at least parts of 16 states at a 30m resolution. For this, we first develop cloud-free and seamless weekly near infrared (NIR), shortwave infrared (SWIR), and normalized difference vegetation index (NDVI) utilizing NASA's Harmonized Landsat and Sentinel-2 (HLS) data. The HLS data are fed into machine learning algorithms, and a multi output variable prediction model is developed to generate weekly 30m resolution maps for the three variables (NIR, SWIR and NDVI). These weekly layers are further integrated with environmental, vegetation, remotely sensed, and geophysical drivers into machine learning algorithms and in-situ observation that were acquired from the BLM Assessment Inventory and Monitoring (AIM) data. Our preliminary results for smaller test area show coefficient of variation (R^2) against modelled and training/test values ranges from 0.72 to 0.80 and a mean absolute error (MAE) of from 3.5 to 13.4 % cover for all aggregated exotic annual grasses, cheatgrass, and medusahead. We anticipate releasing two early prediction 2021 maps (one in May and one in July) for multiple species for the above-mentioned study area.

Effects of *Elaeagnus angustifolia* in South Dakota

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Abstract

Elaeagnus angustifolia (Russian Olive) is an invasive tree in many landscapes in western North America. In these landscapes, *E. angustifolia* invasion impacts native plant biodiversity and soil nitrogen levels. However, little research has examined if these impacts of *E. angustifolia* invasion manifest in the mixed grass prairie of South Dakota. Our main objective was to assess the effect of *E. angustifolia* on plant communities and on soil nitrogen across the state. To meet this objective, two transects per tree were sampled (n= 110). On each transect, plots were located under the canopy, at the canopy, 1.5 and 5 m outside the canopy. At each plot, plant community structure was recorded in 0.5 m X 1 m quadrat and two soil cores were taken and composited. Soil samples were analyzed for total N. Following this, total nitrogen data was standardized to eliminate location affects. Soil and vegetation data were analyzed using ANOVA and Students-T tests. *E. angustifolia* has an effect on South Dakota's plant communities and soil nitrogen. The results indicate that total nitrogen was significantly higher ($p < 0.0001$, F - Test = 46.7807, DF = 3) under the canopy of the *E. angustifolia* than outside the canopy. Also, underneath the canopy of the *E. angustifolia* there was less native plant richness than 5 m outside the canopy ($p < 0.0447$, F- Test = 2.7112, DF = 3). *E. angustifolia* effects the plants and soils of South Dakota by changing soil nitrogen levels and by having lower native richness in the area within 5 m of the tree. With the results in South Dakota being similar to other invaded regions it is likely many of the same affects, like lower native plant diversity and monotypic stands of *E. angustifolia*, are also found in South Dakota.

Plant Invasions and the Potential for Fire Regime Change in the Southern Rockies and Colorado Plateau

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Abstract

Management of invasive plant species purported to be key drivers of fire regime change remains difficult. Most evidence supporting that invasive plants are an important driver of altered fire regimes is extrapolated from observational studies of fire frequency and size before and after invasion rather than through a mechanistic link between fine-scale flammability traits and coarser-scale changes in fire behavior. The distinct influences of species' traits and landscape-level fuel continuity on a fire regime cannot be disentangled without measuring fire behavior. Recent evidence, however, has demonstrated that trait-based flammability can be scaled up to the scale that drives fire behavior. The Southern Rockies and Colorado Plateau ecoregion is undergoing profound change as a result of both fire occurrence and invasive plants, where the latter can exhibit traits that fit them into one of three major flammability strategies. We explore this change by comparing invasive plant dynamics from across the region, leveraging National Park Service (NPS) and National Ecological Observatory Network (NEON) plant inventories. NPS inventories were taken as many as 25 years ago, while the earliest NEON inventories date back only a few years. However, NEON data are taken annually, offering a different temporal resolution for analyzing invasion dynamics. We used these two datasets to analyze the presence and percent cover of 36 different invasive plants that are expected to exhibit a wide range of flammability strategies. Invasive plant richness and diversity were generally higher at NPS sites than NEON sites. Only one species was found at NEON sites that was not present in earlier NPS inventories. The annual resolution in NEON data shows that many species are intermittently present from one year to the next. Next steps include re-inventorying NPS plots, and conducting flammability trials to identify flammability traits and strategies of the species that are driving compositional change.

Fine Fuels Management to Improve Wyoming Big Sagebrush Plant Communities Using Dormant Season Grazing

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Abstract

The invasive annual grass, medusahead (*Teaniatherum caput-medusae*), dominates secondary succession in many sagebrush steppe plant communities, ultimately degrading wildlife and pollinator habitat, decreasing forage available to livestock, and increasing the frequency of wildfire. Medusahead, a winter annual, germinates and sprout in the fall, providing forage for livestock when perennial bunchgrasses are dormant. The focus of our research is to measure the vegetative responses of grazing on medusahead across four treatments: 1) no livestock grazing, 2) traditional grazing between May and September, 3) dormant season grazing from October to February, and 4) traditional plus dormant season grazing. Our specific objective is to promote functionally healthy landscapes within the sagebrush steppe of southeastern Oregon by one, reducing fine fuel loads to lower fire risk, and two, promote perennial bunchgrasses by taking advantage of phenological differences between perennial and invasive annual grasses. The research is taking place on the Vale District Bureau of Land Management Three Fingers allotment, 80 km southwest of Boise, ID. Vegetative cover data was collected in June 2018, 2019, and 2020, and will continue to be collected over the next three years. From 2018 to 2020, annual grass cover increased by 15% in the no graze treatment and 19% in the traditional plus dormant treatment; annual grass cover decreased by 3% in the dormant treatment and 9% in the traditional treatment. Perennial grass cover decreased by 4% in the traditional plus dormant treatment and increased by an average of 6% in the other three treatments. Other vegetation data collected includes density, biomass, and fuel continuity. In general, our results for all variables indicate that three years of dormant season grazing may not be enough time to alter the plant community and fine fuels significantly ($p < 0.05$); hence, these treatments will continue to be monitored.

The Insidious Nature of Kentucky Bluegrass: Exploring Private Landowners' Beliefs and Attitudes

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Abstract

Invasive species in rangelands are an ongoing challenge threatening ecological integrity and the sustainability of agricultural livelihoods. Management responses to invasive species are largely informed by people's beliefs and attitudes about the invader. We focus on the expansion of invasive Kentucky bluegrass (*Poa pratensis* L.) in the northern Great Plains and explore landowners' familiarity with and perceptions of the species.

Based on mail survey responses from 365 private landowners in North Dakota, we conducted a path analysis of the relationships between landowners' familiarity with Kentucky bluegrass, their beliefs about bluegrass, and their attitude about bluegrass. Half of landowners (50%) reported having bluegrass on their rangelands and indicated greater familiarity with the species than landowners who did not report having experienced the invasion. On average, landowners had neutral attitudes about Kentucky bluegrass and did not express strong beliefs regarding a range of desirable and undesirable consequences of bluegrass in rangelands.

Believing that Kentucky bluegrass provides valuable early season forage for livestock and that it maintains its nutritional value were positively related to landowners' attitude about bluegrass, while believing that bluegrass decreases total forage for livestock and that it makes rangelands less pristine were negatively related to bluegrass attitude. Apart from the belief that Kentucky bluegrass is valuable as early season forage, landowners held stronger beliefs that bluegrass had undesirable consequences as their familiarity with the species increased. Overall, landowners' familiarity with Kentucky bluegrass had a negative, indirect effect on their attitude about the species.

Beliefs and attitudes are often shaped by personal experiences and can be key drivers of management behaviors. We found that landowners' familiarity with Kentucky bluegrass was important for understanding their perceptions of the species, suggesting that the insidious nature of Kentucky bluegrass may only affect landowner's beliefs and attitudes once the invasion is quite advanced.

Wild Licorice Control Following Herbicide Application at Two Growth Stages in Mixedgrass Prairie, Alberta, Canada

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Abstract

Wild licorice, *Glycyrrhiza lepidota* Pursh., is a perennial legume native to North America and adapted to sandy mesic and disturbed regions of prairie grasslands. Cattle generally avoid grazing licorice because the plant contains volatile compounds. Wild licorice forms patches spreading by short rhizomes as well as spiny pods that facilitate seed dispersal as cattle move to other areas. It is considered invasive in some western states of the USA and there is anecdotal evidence that licorice density is increasing within Mixedgrass Prairie of southern Alberta, Canada. Field trials were initiated in 2017 at two locations at the Mattheis Research Ranch in southeast Alberta to determine the efficacy of four residual rangeland and pasture herbicides (2,4-D ester; aminopyralid + 2,4-D DMA salt; dicamba; and metsulfuron-methyl + aminocyclopyrachlor) applied on wild licorice at each of two timings (Spring: 3-4 leaf stage; or Summer: early flower) and compared to untreated controls. Wild licorice density and biomass, as well as forb, grass, and litter biomass, were evaluated in 2017 through 2020, and species cover was assessed in 2019 and 2020. In 2017, herbicides reduced licorice densities by 40 to 99% relative to the untreated control, and biomass declined 55 to 100%. Longer term residual activity from summer applied herbicides reduced wild licorice biomass by as much as 98% in 2018 and 95% in 2019 and 2020. Three years following application, non-target native forbs treated with herbicide continued to have reduced biomass (-31% to -90%) relative to the untreated control, though grass biomass increased by as much as 44%. Cover assessments were also made to evaluate plant community changes two and three years after herbicide application. These results highlight the tradeoff in which wild licorice control increased forage availability, but negatively impacted non-target vegetation.

Impact of Eastern Red Cedar Canopy Cover on Herbaceous Forage Biomass in South-Central South Dakota

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Abstract

Eastern red cedar (ERC) (*Juniperus virginia* L.) trees are invading prairies at an alarming rate throughout the Midwest. Such invasion poses a large threat to cattle ranch operations, plant and wildlife populations, and overall ecosystem health. The objective of this study was to evaluate how percent canopy cover in ERC stands and individual tree canopy diameter impact herbaceous forage biomass production. In August 2020, twelve 25 m x 25 m plots with ERC stand canopy cover in low, moderate, and high were established on a ranch in south-central South Dakota along the east side of the Missouri River. Within each plot, canopy diameter (cm) and approximate tree location were recorded for each ERC tree. Eight tree classes were created based on canopy diameter: <1 m, 1-2 m, 2-3 m, 3-4 m, 4-5 m, 5-6 m, 6-7 m, and >7 m. For each plot, up to three trees from each class and ten grassland control locations were selected at random for sampling. Herbaceous forage biomass was measured by clipping four 0.25 m^2 quadrats at half radius of each tree and ten open grassland control locations, totaling 164 trees and 776 samples. We found our twelve established plots ranged from 8-90% ERC stand canopy cover. Herbaceous forage biomass production (kg/ha) decreased linearly as ERC stand canopy cover increased ($y = -38.016 x + 4662$, $r^2=0.9965$, $p < 0.0001$, $n=13$). Herbaceous forage biomass production (g/m^2) displayed a negative exponential relationship with ERC tree canopy diameter (cm) ($y = 454.8e^{-0.004x}$, $r^2= 0.819$, $p < 0.00001$, $n=776$). This biomass reduction resulted in stocking rate (AUM/ha) reduction from 3.28 AUM/ha on grassland control locations to 0.82 AUM/ha with 90% ERC stand canopy cover. Our results showed ERC occupancy lowered stocking rates, grazing capacity, and potential economic return.

Species Distribution Modeling for Lehmann's Lovegrass (*Eragrostis lehmanniana* Nees) Under Future Climatic Models

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Abstract

Only within the last few centuries have geographic barriers due to improving global transportation and networks of commerce been eroded so that plant and animal species have been widely introduced beyond their original ranges. Species have been moved across continents, accidentally or intentionally, and can significantly impact their new ranges. Lehmann's lovegrass (*Eragrosits lehmanniana* Nees) is a South African perennial grass introduced to North America for cattle fodder since the 1930's. Populations of *E. lehmanniana* have been expanding within the Southwest for years, with potential effects on local native communities and livestock foraging behavior and nutritional value. Using open-access citizen science data in Texas, we created maps using available bioclimatic variables provided by WorldClim and run through MaxEnt habitat suitability models. We found that the model predicted present locations of Lehmann's Lovegrass (AUC = 0.945). Using predicted future climate models, we then simulated distribution models; these show a potential spread throughout most of the drier areas of the state, specifically the arid deserts and northern prairies of Texas. The management and control of Lehmann's lovegrass should be a priority to conservationists, managers and ranchers that would like to preserve diverse nutritious rangelands for cattle and native fauna.

Ecologically Based Weed Management in Rangelands

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Abstract

Centurea maculosa (Spotted knapweed) spreads rapidly and displaces the native plants that are crucial to British Columbian grasslands. Traditional weed management focuses on killing the weeds rather than addressing the ecological process that allowed the invasive to establish. Our objective was to restore desirable perennial grasses to a knapweed invaded rangeland by investigating soil chemical properties and wood ash ammendment, herbicide effects and three different seed mixes. The research took place at the Laurie Guichon Memorial Grasslands Interpretive Site outside of Merritt, BC. The majority of the area is covered in 50% or greater of spotted knapweed. A split-plot experimental design was used to test different combinations of herbicide, wood ash concentration (0, 1 and 10 Mg ha^{-1}) and seed treatments (Bluebunch wheatgrass/Sandberg's bluegrass, crested wheatgrass and intermediate wheatgrass). An ANOVA test with Tukey post hoc determined herbicide significantly lowered knapweed cover ($p<0.0001$) while ash had no significant effect on knapweed cover. There were no significant results within seed treatments in either year of study. Herbicide treated plots created a significant spike of plant available NO_3^- and ash amendments significantly decreased the supply of NO_3^- in herbicide treated plots, however there was not effect on NO_3^- or spotted knapweed in the unsprayed plots. Where herbicide decreased knapweed cover to almost 0, it facilitated a 55 (±26)% percent increase of *Bromus tectorum* (cheatgrass). These results play an important role to help land managers make decisions on invaded western rangelands.

Response of Seeded Species to Three Common Herbicides Used for Downy Brome (*Bromus tectorum*) Control

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Abstract

Chemical control of downy brome (*Bromus tectorum*) is one of the primary tools employed to restore degraded rangelands in Western North America. However, many herbicides used to control downy brome may also inadvertently inhibit germination of desirable seeds planted following chemical treatment. We evaluated three herbicides: Imazapic (Plateau), Indaziflam (Esplanade), Rimsulfuron (Matrix) and Indaziflam/Rimsulfuron in combination. We compared each product's ability to control downy brome over multiple (2) years, as well as the unintended inhibition of seeded species in treated areas one or two years after chemical application. Six common restoration species (crested wheatgrass, Siberian wheatgrass, alfalfa, blue flax, forage kochia, and Wyoming big sagebrush) were planted into treatment areas either the same year as herbicide application (single entry), one year following herbicide application (multiple entry), or immediately prior to herbicide application (sprayed after seeding). Downy brome cover and density of seeded species within each treatment was measured the following spring. While Indaziflam consistently achieved the highest and most residual control of downy brome —especially when used in combination with Rimsulfuron—it completely prevented germination of nearly all seeded species, even two years after chemical application. Imazapic achieved moderate and inconsistent control of downy brome, but also had the least severe impact on germination of seeded species. Rimsulfuron achieved excellent control of downy brome for the first year following application, with a correspondingly negative impact on seeded species; however, nearly all effects of this herbicide—both positive and negative—disappeared by the second year.

INHABIT: a Web Application to Deliver Habitat Suitability Models and Bridge the Scientist-Practitioner Divide

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Abstract

Many practitioners are hampered by the scope of the invasive species problem compared to available resources that combat invasive species. Habitat suitability models for invasive species can provide practitioners with information to advise watch lists and target population searches. While many suitability models exist, there is often a divide between researchers creating these models and practitioners who may find them useful in informing land management actions. We have formed a scientist-practitioner partnership to create national models for priority species that are integrated into the Invasive Species Habitat Tool (INHABIT), a web application displaying visual and statistical summaries of nationwide habitat suitability models. The models are based on aggregated occurrence data and a species-specific set of predictors from a library of environmental predictors we have assembled. The models are built following a common protocol, promoting model repeatability and credibility. Managers provide feedback both on the models and INHABIT's features, iteratively improving the content and functionality of INHABIT. This app is designed to provide practical information leading to enhanced land management actions, including mapped products with interactive thresholds to define suitability based on management objectives (with field-device compatible download options), information
on modeled environmental relationships, and tabular proximity summaries to inform management area watch lists. Based on comments and suggestions of practitioners, INHABIT is actively evolving to help bridge the gap between scientists and practitioners.

Western Juniper Control in Northeastern California

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Abstract

Western juniper (*Juniperus occidentalis*) has invaded over three million acres of sagebrush rangelands in northeastern California becoming the dominant vegetation over the past 100 to 140 years. While juniper is a native species and old-growth sites in the 1000 year old range are not uncommon, juniper was largely contained to fire safe locations, such as rocky shallow soils that naturally lacked understory vegetation to carry fire. Juniper is a very well adapted and competitive species. Over time, it will outcompete understory vegetation for limited soil moisture, sunlight, and space. Although juniper can be milled for flooring or cabinets and used for firewood, it does not have a high commercial value. The first step to juniper control is conducting a pre-treatment site assessment and selecting a site. Factors such as soils, aspect, precipitation, juniper dominance, and understory plant community will be discussed. The next step is selecting your treatment techniques which could include a combination of mechanical, chemical, hand, and fire. After treatments are completed, post treatment management including rangeland restoration, seeding, and grazing is important. The last step is future follow up treatments and management. Controlling juniper provides forage and habitat for livestock and wildlife by restoring a more productive and diverse understory plant community. Restoring these invaded rangeland ecosystems also improves hydrologic function and subsurface flow in an already arid environment.

Slowing the Invasive Grass-Fire Cycle in Rangelands of the Southwestern U.S.

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Abstract

Invasive non-native grasses can rapidly transform rangelands, incurring large socioeconomic and environmental costs. While invasions are occurring globally, shifts in plant community composition, productivity, nutrient cycling, and hydrology triggered by invasive grasses are occurring at a rapid pace in the southwestern US. These transformations are further accelerated because many invasive grasses both enhance fire risk and can recover faster than native species following fire, thereby creating a positive feedback cycle that increases their spread. Restoration practices, including invasive grass control and seeding native species can slow the invasive grass-fire cycle and promote recovery of degraded rangelands. We present new technologies to detect invasive grasses and monitor their spread, assessments of treatment and cost-effectiveness, and results from a networked experiment that tests restoration practices across the southwestern US. This information can be used to slow the invasive grass-fire cycle and improve rangeland condition.

Effects of Indaziflam Treatment on Seed Bank Density and Richness in a Sagebrush-Grassland Plant Community in Sublette County, WY US.

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Abstract

Mitigation of annual grass invasion is critical to halting the conversion of native rangelands to fire-prone, annual grass-dominated communities. The herbicide indaziflam (Rejuvra®, Bayer) is a promising new tool that may allow managers to selectively deplete annual grass seed banks in plant communities that continue to support desirable perennial vegetation. The potential for non-target impacts to the seedlings of other species in the seed bank is not well-understood. To assess the potential for non-target impacts, we collected seed bank samples from three treatment (73g ai/ha) and control plots in an invaded sagebrush-grassland plant community near Pinedale, Wyoming. Plots were treated with a helicopter in September 2016 and samples were collected in October 2019, three years after treatment. Because indaziflam is more likely to have effects on seedlings that germinate near the soil surface, samples were divided into shallow (0-1cm) and deep (1-5cm) seed banks. Germinating seedlings from these samples were tracked over a period of 20 weeks in a greenhouse with regular watering, and these data were used to compare the density and richness of the seed bank between treatment and control plots. Preliminary results suggest that: (1) the perennial seed bank is very sparse at the research site; (2) the majority of seeds occur in the shallow seed bank; and (3) indaziflam treatment appears to have reduced the richness and density of the native species seed bank, with most of the impacts occurring to native annuals.

Annual Imazapyr Application Effects on Old World Bluestem and Native Vegetation

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Abstract

Imazapyr application has been effective at reducing old world bluestems in pasture while allowing many native warm-season grasses to survive and increase, but multi-year applications have largely gone undocumented. On an Ellsworth County, KS pasture site beginning in 2017, imazapyr was foliar applied annually for 3 years in a large pasture where Caucasian bluestem cover was 51.1% prior to application. After two years of application, Caucasian bluestem seedling recruitment in the third growing season was 0.02 seedlings/ft^2. Caucasian bluestem cover was reduced to 0.2% after the third year of application in 2019, while big bluestem, little bluestem, and indiangrass combined increased from 9.3% to 26.0% cover. Marestail and western ragweed dominated the plant canopy vacated by old world bluestems, accounting for 42.9% cover in 2019. Reseeding to native grasses occurred in spring 2020, and establishment resulted in 1.5 native seedlings/ft^2. Greater native seedling densities were highly correlated (R=0.78) with pasture sites with high Caucasian bluestem cover prior to herbicide treatment. This suggests native grass establishment can be successful within 3 years of Caucasian bluestem reduction and that negative allelopathic effects on native grass seedling growth may diminish within that time period.

The Evaluation of Herbicides for the Management of King Ranch and Kleberg Bluestems in South Texas

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Abstract

King Ranch bluestem (*Bothriochloa ischemum*) and Kleberg bluestem (*Dichanthium annulatum*) are two grass species originally introduced in pastures for hay production and erosion control, which have become invasive in many areas of Texas. A field experiment was conducted in 2019 near Banquete, TX to determine the efficacy of fifteen different herbicide treatments, rates, and timings for long-term management. The treatments were arranged in a randomized complete block design (RCBD) with 3 by 6 meter plots consisting of three replications of each treatment and one nontreated control (NTC). Bluestem density counts were conducted within a 0.3 by 0.3 meter quadrat placed at three random points in each plot bi-weekly from spring to fall. Herbicide applications were made at three timings (A-April 11th, 2019, B-June 7th, 2019, and C-October 8th, 2019). At 47 days after application B there was a 55.32-42.91% decrease from treatments with pendimethalin (2.77 kg ai ha^{-1};A) + glyphosate (1.26 kg ae ha^{-1};A) followed by (fb) glyphosate (1.26 kg ae ha^{-1};B) and indaziflam (43.87 and 73.12 g ai ha^{-1};A) + glyphosate (1.26 kg ae ha^{-1};A) fb glyphosate (1.26 kg ae ha^{-1};B). At the final evaluation, 25 days after application C, treatments of indaziflam (43.87 and 73.12 g ai ha^{-1};A) + glyphosate (1.26 kg ae ha^{-1};A) fb glyphosate (1.26 kg ae ha^{-1};B) fb glyphosate (1.26 kg ae ha-^{1};C), pendimethalin (2.77 kg ai ha^{-1};A) + glyphosate (1.26 kg ae ha^{-1};A) fb glyphosate (1.26 kg ae ha^{-1};B) fb glyphosate (1.26 kg ae ha^{-1};C), and glyphosate (1.26 kg ae ha^{-1};A) fb glyphosate (1.26 kg ae ha^{-1};B) fb glyphosate (1.26 kg ae ha^{-1};C) had 79.40-67.02% decrease in bluestem density. This study revealed that several treatments were effective at reducing invasive bluestem density and is currently being repeated in 2020 to gather additional information

Novel Perennial Grass Fertilization Strategies for Inducing Allelopathic Responses in Annual Grasses

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Abstract

Annual grasses have become a massive problem in the Western United States and scalable methods for diminishing their distribution are few. New and novel strategies are necessary. Weeds are not new to the Western landscape, yet the extent of annual grass expansion is unprecedented and worsened by soil disturbance. Edaphic disruption caused by fire, climate change, excessive grazing, drought, road building and other soil-degrading activities has been shown to change the mobility of soil nutrients. Increases in annual grass density have especially been correlated to mobilization of soil nitrogen. Likewise, nitrogen fertilization has been shown to stimulate the growth annual grasses. However, rangeland plants require a full spectrum of macro and micronutrients. In this presentation data from research sites in Montana and Utah will be used to demonstrate a novel rangeland fertilization approach. Plots were established at multiple sites using low or no nitrogen fertilizers to promote the growth of desirable rangeland plants and particularly perennial grasses. Results collected over several years at multiple sites show reproducible declines in annual grass cover while increasing levels of perennial native grasses. Through apparent allelopathy, elevated levels of soil micronutrients have been shown to promote the growth of late successional rangeland plants allowing them to outcompete early successional weedy species such as cheatgrass. Sites three to four years in age show progressive increases in perennial grass cover following treatment with commensurate reductions in annual grass cover. New perennial grasses are able to establish from seed or from seedbank propagules following treatment filling in openings previously occupied by annual grasses. These promising findings suggest that creating micronutrient-dense soil may be a viable method for restoring both soil health and perennial grassland vigor.

Response of Tanglehead (*Heteropogon contortus*) to Prescribed Burning and Cattle Grazing

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Abstract

Tanglehead (*Heteropogon contortus*) is a drought-tolerant bunchgrass native to South Texas; over the past decades it has expressed invasive tendencies that are negatively affecting cattle grazing and the wildlife biodiversity value of the area. In the absence of cattle, tanglehead spreads rapidly and creates thick, monotypic stands that are unpalatable to cattle and outcompete native species. Prescribed fire removes mature, coarse vegetative material and inducing new shoots with higher nutritive value, therefore, we tested the hypothesis that concentrated cattle grazing on sprouting tanglehead in burned areas would reduce the coverage of tanglehead and allow for an increase of plant species richness on these rangelands. The objectives of this study were to determine the effects of prescribed fire and cattle grazing on 1) the composition of a plant community dominated by tanglehead; and 2) cattle use of tanglehead-dominated areas treated with prescribed fire. In Jim Hogg County, Texas, six patches (~ 4 ha each) of a 95.5 ha tanglehead-dominated pasture were selected for sampling, and three patches were separately treated with prescribed fire in February 2019. The entire pasture was grazed continuously by free-range cattle at a stocking rate of 0.1 AU/ha/yr since August 2016 with 10 mother cows. Sampling took place every 30-90 days over a 22-month period. For each plot, three grazing exclosures were sampled inside and outside using one quadrat (0.25 m^2), a transect of 25 m was sampled with a quadrat at each meter, and all vegetation within all quadrats was clipped. Recorded variables for all quadrats were species richness and cover, bare ground, litter cover, and forage standing crop. The goal of this research is to provide landowners and managers with a method that allows for the use of livestock as a purposeful tool to manage tanglehead to benefit wildlife habitat, while maintaining livestock performance.

Measuring & Monitoring Ecosystems

LandPKS for Rangeland Inventory and Monitoring – New Features and Future Directions

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Abstract

Rangeland inventory and monitoring mobile apps, including those that provide access to the Land Potential Knowledge System (LandPKS), are improving the efficiency of rangeland monitoring. Within LandPKS, a number of the tools have been updated in the past year, and users of the app are invited to contribute to the design of a new version will serve as a gateway to a variety of rangeland and pasture data, information and knowledge sources. This paper briefly describes some of the recent updates, and future opportunities. The three primary new features are an expanded SoilHealth module, a Habitat module, and a Utilization tool. The SoilHealth module provides a complete set of data entry forms necessary to complete the 2020 NRCS Cropland In-Field Cropland Soil Health Assessment. While designed for croplands, many, if not most, of the indicators are relevant to rangelands. One process missing from the Assessment is runoff and erosion. This is captured in the erosion indicators that have been retained from the original SoilHealth module, and include the Rangeland Health indicators Water Flow Patterns, Rills and Gullies. The Habitat module provides information on habitat requirements for species whose range includes the location queried using the phones GPS, or the map function at the bottom of the screen. Looking ahead, the app will be rebuilt to focus specifically on rangelands, making it both easier to use, as well as more useful. We expect it to include greater flexibility in vegetation monitoring, while still retaining NRCS-NRI and BLM-AIM compatibility. The photo monitoring function will be redesigned to make it much easier to use. Most importantly, users will be able to more easily access and interpret data and information from EDIT, the Landscape Data Commons, and either directly or through these tools, to explore scenarios with modeling tools such as AERO.

Trends of Fractional Rangeland Components Across a 1985-2020 Time-Series

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Abstract

Rangelands across the Western United States are highly dynamic through both space and time in response to disturbance, climatic variation, and biophysical patterns. The USGS has developed fractional components stretching across a 1985-2020 time-series using 30-m Landsat satellite imagery, designed to capture this variation. The fractional components enable detection and evaluation of both abrupt and gradual change, facilitating improved understanding of rangeland dynamics. We report range-wide trends in component cover and their relationships to known drivers of change. Our results show a net decrease in shrub, sagebrush (*Artemisia* spp.), and herbaceous cover. Change was pervasive, with over 90% of pixels experiencing change in component cover over the time-series, but the majority of this change was gradual (i.e., within-state change with typically less than 10% change in cover). Sensitivity testing revealed that bare ground and shrub cover change of >6.1% and > 2.9%, respectively, were captured in more than 50% of cases. We present several case studies demonstrating the local application of the time-series data. Validation of remote-sensing products is critical to increasing user confidence, relative to long-term monitoring plots we found strong temporal associations with the time-series data, with an average R^2 of 0.45 and Root Mean Square Error (RMSE) of 5.47%. Validation results relative to data from a series of high-resolution predictions showed an average R^2 of 0.63 and RMSE of 5.5%. Finally, we discuss plans to expand our time-series work to the future using cloud processing solutions.

Evaluation of the Environmental Potential Use of Nutrient-Rich Ash Residuals as a Fertilizer in Soil

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Abstract

Wood chips and chunks, bark and wood fiber, also known as hog fuel, are the by-products of an engineered wood manufacturing facility. By burning the hog fuel in biomass power plants, electricity is generated, steam is processed, and ash residuals are produced as a by-product. In Canada, even though the ash residuals are high in nutrients, they are still considered as a waste product and normally stored at a landfill. In order to prevent the ash residuals from building up in landfills and creating an environmental hazard, and to reduce costs, the environmental potential use of the ash residuals as a fertilizer in agriculture is evaluated, which is done in collaboration with a biomass company and an agricultural research company based in British Columbia. In the study, the nutrient-rich ash residual by-products are agriculturally pH-treated with elemental sulfur for six months and then applied to testing fields as a fertilizer every spring. The pH, conductivity, moister content of the test fields, as well as the quantities of various macro minerals (calcium, phosphorus, magnesium, sodium, potassium and sulfur), trace minerals (manganese, copper, chromium, zinc, molybdenum, nickel, cobalt and selenium) and toxic elements (lead, arsenic, cadmium and barium) in the fields are monitored by testing the soil samples collected from these fields throughout the growing seasons between 2018 and 2020. Mehlich-3 extraction and wet digestion are applied on each soil sample to obtain two solutions for quantifying exchangeable elements and total recoverable elements, respectively, in the soil samples by using flame atomic absorption spectrometry (FAAS), capillary electrophoresis (CE) and inductively coupled plasma-mass spectrometry (ICP-MS). The changes of every factor monitored in the field over the growing season and over three years are compared in order to evaluate the impact of using the ash residuals as a fertilizer in agriculture.

What's Happening to the Growing Season? Evaluating Changes to Vegetation Phenology Across the Northwestern Plains

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Abstract

Seasonal and yearly variations in growing season productivity and event timing (phenology) are controlled by different environmental and climatic factors. Although influences such as higher temperatures have led to an earlier starts to spring, later ends of fall, and higher productivity across much of the globe, there is considerable variability in the magnitude and direction of these changes within regions and across community types. We examined the relative strength of temperature, precipitation, and change over time in driving phenological measures across space and vegetation types in the U.S. Northwestern Plains. We used datasets for phenology, derived from satellite imagery (1 x 1 km), climate, and vegetation community types to 1) analyze interannual trends, and 2) model the associations of potential factors in driving phenological measures. We found that >40% of pixels had significant trends in the Julian date for when the growing season ended compared to 23% in when the growing seasons started, with most pixels moving towards later start and ending dates. More pixels (38%) had significant interannual trends in peak productivity than in season-long productivity (28%), with key differences among community types. Whereas temperature primarily controlled timing-based events and precipitation more strongly controlled productivity measures, the influences of climate drivers varied. For example, annual precipitation predominantly increased peak and season-long productivity; however, typically whereas higher mean annual temperature increased peak productivity, it decreased season-long productivity. We also identified areas where additional factors, such as recovery from disturbance and changes to agricultural practices, contributed to season-long productivity and end of season patterns. Recognizing variations in phenology across space, time, and vegetation communities provides important context for rangeland management. Furthermore, consideration of multiple factors to describe the growing season provides a richer understanding of spatio-temporal patterns that can help predict implications of ecosystem responses to future scenarios.

The Last Remaining Intact Grasslands on Earth

Rheinhardt Scholtz, Dirac Twidwell

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Abstract

Grasslands are the most imperiled ecosystem on the planet. We have lost >60% endemic diversity and safe operating space in an ecosystem that is the least protected globally. Basic ecosystem services such as water provision and regulatory services provided by grasslands are threatened. Amidst 21st century pressures of global change such as woodland expansion, afforestation and climate change, our study identified the last remaining large and intact grasslands on Earth. This was done by quantifying the degree of landscape intactness on all pure grassland areas i.e. true prairies and all grassland steppes on Earth. Only seven regions represent the last remaining large and intact (at least 75% area) grasslands on the planet. They occur in the temperate regions of North America (Wyoming steppe and Nebraska Sandhills grassland), Asia (Selenge steppe, Altai steppe, Ordos steppe and Mongolian-Manchurian grassland) and subtropical Africa (Serengeti grasslands). These culturally-rich, biodiverse areas form critical parts of migration pathways and many livelihoods depend on their persistence for survival. While these regions are not immune from current global threats, this presentation showcases how these are our last hope for grassland strongholds under anthropogenically-driven global change.

Monitoring Grassland Phenology: Relating Vegetation Characteristics to NDVI to Provide Near-Real Time Rangeland Assessments Throughout the Growing Season

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Abstract

Tracking seasonal changes in rangeland productivity – the timing and amount of forage -- has become increasingly difficult with increasingly unpredictable occurrence, duration, and intensity of drought as well as other disturbances such as wildfire and grazing. Remote sensing can provide a means for managers to "check-in" on forage production and development. By using MODIS (Moderate Resolution Imaging Spectroradiometer) satellite data, the NDVI (Normalized Differential Vegetation Index) of grassland areas as small as 15 acres can be calculated on short time scales (e.g. a week). However, calibration of satellite imagery with on-the-ground rangeland productivity and condition metrics is lacking. In an effort to relate NDVI to grassland vegetation characteristics that managers regularly use in their assessments, we measured vegetation characteristics across 21 sites every 1-2 weeks throughout an entire growing season on Buffalo Gap National Grassland, a 242,000 hectare mixed-grass prairie in western South Dakota, USA. At each site, the leaf developmental stage of dominant C_3 and C_4 grass species, grazer presence, % cover of plant functional groups and bare ground, and visual obstruction readings (VORs) were measured. Each site was located in the center of a MODIS 250m x 250m pixel (~15 acres) enabling vegetation characteristics to be correlated with NDVI. Weekly NDVI was highly correlated with VOR and leaf developmental stage of the dominant C_3 grass, *Pascopyrum smithii*. Individual site characteristics, such as heavy grazing, significant forb and shrub components, and temporary flooding, can reduce the accuracy of the correlation between NDVI and vegetation characteristics. However, overall phenology could still be accurately portrayed when averaged across multiple pixels. The relationship of NDVI and vegetation characteristics is currently being used to create and inform PhenoMap, a web mapping application that features weekly land surface phenology updates based on NDVI.

Assessing the Impacts of Scale on Estimates of Grazing Intensity Derived from Livestock Global Positioning System Collars

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Abstract

Understanding the short- and long-term effects of domestic livestock grazing is essential to effective rangeland management. However, current estimates of livestock use rely largely upon in-field measurements that are difficult to scale up to a pasture or landscape level useful in making management decisions. Our goal was to deploy low-cost GPS collars on domestic cattle herds to collect location data for developing reliable estimates of grazing intensity at useful spatiotemporal scales. Our objective was to analyze how changes to the following 5 factors influenced the recommended proportion of collars needed to obtain accurate grazing intensity estimates: the size of the pasture, the size of the herd, the size of the pixel, the GPS collar sampling frequency, and the length of the grazing period. GPS collars were allocated to ≥45 cows per pasture at study sites in Idaho and Oregon in 2019-2020. Livestock grazing intensity was calculated using a simple occurrence method that accounted for the number of grazing animals, the number of active GPS collars in a given time step, and the size of the grazing area. A total grazing intensity surface using all GPS points for a given pasture across the entire grazing period was generated. To assess how spatiotemporal changes influenced the recommended proportion of collared animals, a subsetting analysis was employed in which GPS collars (from n-1 to 1) were randomly excluded and the grazing intensity was recalculated for the pasture using the remaining points. An average percent difference and a Cohen's kappa statistic were generated between the original grazing intensity surface and each excluded collar surface to analyze differences between the two. Results suggest that the recommended proportion of GPS collars is a function of pasture size. More collars are required in larger pastures to accurately assess the grazing intensity of the herd.

Quantifying Aspects of Land Health at Watershed Scales in Colorado Using Broadscale Data

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Abstract

The Bureau of Land Management (BLM) adopted a set of state land health standards for Colorado in 1995 that describe the physical and biological conditions required for healthy lands and sustainable uses. These land health standards are commonly assessed as part of the grazing permit renewal process using indicators that are measured with field-based data collected from multiple individual sites within allotments. However, BLM guidance suggests assessing land health at larger spatial scales, such as fifth-level watersheds. We explored the potential for quantifying aspects of land health at watershed scales using indicators that can be measured with existing broadscale spatial datasets. We present an exploratory case study quantifying selected land health indicators at fifth-level watersheds within a BLM field office in Colorado. We limited consideration of potential broadscale datasets to those that are publicly available, have a published accuracy assessment, and have adequate thematic detail for priority land cover types in Colorado. We found that multiple indicators can be reliably quantified using these datasets and are relevant to Colorado land health standards. We suggest that a broadscale approach to quantifying aspects of land health at watershed scales can complement current, field-based monitoring and assessment efforts including BLM's Assessment, Inventory, and Monitoring (AIM) program and Interpreting Indicators of Rangeland Health (IIRH) by providing a broader context for land health assessments conducted at the scale of individual allotments. Integrating broadscale perspectives into the land health assessment process may help managers identify target areas where additional, field-based sampling is needed and instances where the potential cause of observed conditions is operating at a spatial scale that is broader than the individual allotment, such as when increases in bare ground, specific native vegetation types, or invasive species are occurring across multiple allotments in association with changes in landscape-level conditions or disturbances.

An Explicit Estimate of US Carbon Stocks on Indigenous Lands in the CONUSA

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Abstract

Drylands cover some 41% of the terrestrial land surface and provide 36% of the World's human population an estimated $18.1 trillion in ecosystem goods and services that include global climate regulation and food security, yet drylands are highly vulnerable to climate change. Recently, the 2018 Second State of the Carbon Cycle Report (SOCCR2, https://carbon2018.globalchange.gov/chapter/7/) stated that "Scientific data and peer-reviewed publications pertaining to carbon stocks and fluxes on indigenous lands in North America are virtually nonexistent." However, a number of available datasets and peer-reviewed papers have implicitly provided time series estimates of carbon dynamics on Tribal drylands. As a first step we have developed the Tribal cropland and rangeland in drylands footprint (C&RAF) that provides the percentages of these cover types in the ~2.3% of land in the USA that was left to the Tribes. To conduct this spatial analysis, we developed a Geographic Information System (GIS) database for the period between 2000 to 2018 that consisted of the Humidity/Aridity Index, US Tribal land boundaries, and the Landsat-derived National Land Cover Dataset (NLCD) from between 2000 and 2016. Secondly, we have assembled satellite-based remote sensing datasets that measure carbon dynamics including the Landsat-derived net primary productivity (NPP) 30-m dataset from 1984 – 2019. We will conduct a Zonal analysis to produce NPP estimates for each Tribe's cropland and rangeland NPP using the C&RAF from 1984 to 2019, thus providing an explicit measure of carbon dynamics on US Tribal lands in Drylands of the CONUSA.

Combining Forage Production Models with Summer Climate Scenarios

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Abstract

High interannual variability of forage production in semi-arid grasslands leads to uncertainty when livestock producers make decisions. To withstand low-production years, mainly connected to drought, producers often use conservative stocking rates. However, conservative stocking in high production years creates missed opportunities in terms of unused forage. Flexible stocking has been recommended as a more cost-effective alternative. In order to implement flexible stocking or other management actions, producers need an estimate of total annual forage production early in the growing season. We have developed a forage production model that estimates the amount of annual forage using environmental and weather variables and the remote sensing-based Normalized Difference Vegetation Index as a proxy for grassland productivity. The method was initially developed for Nebraska Sandhills upland grasslands and has been recently applied to other semi-arid grasslands in the western U.S (validation on hold-out data $R^2 = 0.96$). Since the model uses summer temperature and precipitation as input variables, the model output cannot be produced early enough to inform in-season decisions. Therefore, we developed a method that creates scenarios of possible end-of-season forage production. These scenarios are developed using the forage production model in combination with up-to-date weather inputs (from winter and spring), and a range of possible summer precipitation and temperature values. Specifically, we used historical weather data (1950-present) for the summer season and created representative maps of abnormally low, normal, and abnormally high temperature and precipitation. Using these maps, we created summer season climate scenarios (e.g. cool and dry, warm and wet) that serve as the model input to produce a possible range of end-of-season forage production. When provided on an operational basis, these scenarios can serve as a decision support tool for livestock producers and rangeland managers.

A Quantitative and Mappable Soil-Geomorphic Framework for Ecologically-based Management Units

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Abstract

Land management decisions require context to understand how a landscape may respond under different scenarios, circumstances, or alternatives. As rangeland ecologists' understanding of non-linear ecological dynamics have evolved into state and transition model (STM) theory, more emphasis has been put into discerning and mapping the soil, geomorphological, and climate parameters that mediate ecological dynamics. The USDA Natural Resources Conservation Service (NRCS) Ecological Site Description (ESD) inventory has become the foremost system in classifying lands into unique ecological units based on similarity in STMs. However, completing an exhaustive inventory of ESDs in the United States has proved challenging, and there has been criticism of both the inconsistent level of detail in areas completed and the ability to objectively support some assertions made in exiting ESDs. To address these issues, this study examines ESDs in the diverse Upper Colorado River region, where ESDs are only partially complete, to look at quantitative approaches to generalizing ecological site concepts based on unifying underlying soil, geomorphology, and climate drivers. Using existing ESD and vegetation monitoring plot data, results show that a simple hierarchical soil geomorphic unit (SGU) framework based on topographic mediation of moisture, soil salinity, soil depth, slope, rock content, and soil texture can represent much of the ecological dynamics catalogued in ESDs. Analysis of reference production data, STM state attribution, and regional plot monitoring data show the new SGUs represent more variation than commonly used climate parameters. SGUs were also accurately mapped following recent advances in digital soil mapping. An optimized combination of SGUs with climate zones derived from an aridity index and maximum temperature of the hottest month resulted in an ecological site group framework that condenses over 826 unique ecological site records at various stages of completeness in the regional soil survey down to 35 easily mappable groups.

A UAS-Based Protocol for Monitoring Stream and Riparian Restoration at the Reach Scale

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Abstract

Interest has increased in the use of Beaver Dam Analogs (BDAs) and similar low-tech process-based restoration (LTPBR) techniques for stream and riparian restoration. However, procedures to quantify the ecological effects of these restoration practices at reach to watershed scales have lagged in comparison to implementation. With low risks associated with some restoration practices like LTPBR, monitoring for broader ecological impacts is often overlooked or conducted via qualitative assessments, limiting managers from gaining the detailed perspective needed to report treatment success and overall impacts. Monitoring the effectiveness and the long-term ecological impacts of treatments, like BDAs, is required to inform managers if objectives have been met and to guide maintenance to ensure effective restoration. We propose a quantitative monitoring protocol that focuses on reach-scale indicators related to riparian and stream processes and their ecological function. We utilized unmanned aerial systems (UAS) along with in-field measurements across 33 stream reaches from seven BDA projects in Idaho spanning three different ecosystems. We quantified channel-spanning structure densities, beaver densities, channel lengths, flow, gradient, and proportions of riparian vegetation groups, different surface water types, potential riparian/stream area and inaccessible area within the valley bottom. We describe the protocol and demonstrate its application in multiple stream ecosystems. With a quantitative monitoring approach, effects of riparian and stream restoration can be documented, providing detailed descriptions of the effectiveness of these treatments on different systems and specific functions that managers hope to restore.

New Possibilities for Large-Scale Tracking of Management Outcomes in Rangelands

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Abstract

With the increasing costs and demands to manage for regional- and biome-scale rangeland challenges like woody plant encroachment and annual grass invasions, there is a critical need to quantify management outcomes at the scales of these challenges. Novel technologies paired with field monitoring now permit rangeland monitoring at unprecedented scales, empowering complete spatial coverage of western US rangelands and annual temporal updates. Here, we showcase an approach using next generation vegetative biomass monitoring data to transparently track and communicate management outcomes at multiple temporal and spatial scales. We apply this approach to three conservation priority landscapes that have received large-scale management treatments to enhance both livestock forage and threatened species populations: the Warner Mountain Priority Landscape for Conservation, Oregon (Sage-Grouse), the Loess Canyons Biologically Unique Landscape, Nebraska (American Burying Beetle), and the Lesser Prairie Chicken Initiative Shortgrass Prairie Focal Area (Lesser Prairie Chicken). Our results show high spatial and temporal variability in brush management, prescribed fire, and grazing treatment outcomes across scales. We also discuss how a multi-scale approach to implementing and communicating monitoring is key to adapting management to adapting management and achieving desired outcomes.

Monitoring and Management for Sustainable Populations of Blue and Valley Oaks

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Abstract

On many rangelands in the southern San Joaquin Valley and Central Coast, mature oaks (greater than 50 years of age) dominate local blue and valley oak populations. Decades of research in the state identified a biological bottleneck due to the rare establishment of oak seedlings. This problem is exacerbated at lower elevations and the more southern areas of the valley. Older oaks die from drought, pests, disease, natural senescence while young oak recruitment is scarce. Land managers concerned about conserving their oak populations seek to sustain mature oaks, promote recruitment, and plant new trees.

The lack of capacity to address these concerns suggests that the existing body of research has yet to be broadly disseminated or adopted into practical, successful oak management and regeneration. Livestock producers and other land managers have expressed significant interest in continued research and information to address oak management challenges including how to diagnose and prevent causes of oak mortality (prolong mature oak lifespans) and how to increase young oak recruitment.

To address these concerns a project has been initiated that will establish long-term monitoring sites throughout the southern San Joaquin Valley and Central Coast regions. Monitoring will serve to: define mature oak mortality rates; define seedling recruitment and survival rates; and correlate past and present management strategies to oak demographics.

Outreach & Education

The Next Evolution of California's Ranch Water Quality Planning Program

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Abstract

The University of California recently unveiled the next evolution of the Ranch Water Quality Planning (RWQP) program. Since its inception in 1995, the RWQP program has delivered more than 80 short courses in 35 counties to over 1,000 ranching and community members, resulting in more than two million acres of rangeland placed under water quality plans. RWQP short courses have been highly dependent on University of California Cooperative Extension academics to organize and deliver workshops using a flexible curriculum framework to adapt educational content to local issues and regulatory programs. This next evolution of the RWQP program centers on a multi-media package that enables UC Cooperative Extension (UCCE), and non-UCCE people and organizations alike, to organize and convene a series of locally-relevant RWQP workshops with the purpose of coaching ranchers and land manager to build their own ranch water quality plan. The core of the package is a RWQP Instructor's Guide and Lesson Plan that consists of nineteen lesson plans organized into six learning modules including twenty-nine educational and instructional videos curated on YouTube. The RWQP Instructor's Guide is available as a downloadable PDF document and on the UC Rangelands website. The Guide provides the resources and tools to plan and implement Ranch Water Quality Planning workshops and field days for grazing livestock producers, agency staff, and other stakeholders interested in grazing management and water quality. These new resources provide a wealth of contemporary information about water quality management on rangelands based upon more than thirty years of research and education conducted by UC Cooperative Extension and partners. This presentation reviews the evolution of the RWQP program and the intended use of the Instructor's Guide and demonstrates how to access and use the RWQP Instructor's Guide and its major components.

The State of Rangeland Plant ID Education in North America

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Abstract

In North America, Rangeland Plant Identification (Plant ID) classes are offered by a broad group of colleges and universities, though little research has investigated effective learning and teaching in these classes. To assess the state of Plant ID education and begin identifying evidence-based instructional practices for these classes, we conducted surveys of instructors (in 2018), and current and former students (in 2020). We used correlation analysis and the nonparametric Wilcoxon test to analyze the effect of institutional, instructor, and course characteristics on Final Plant ID Quiz scores as a measure of student proficiency at identifying rangeland plants. The survey of instructors received 30 responses from 26 different institutions with a mix of institution types, student populations, and SRM Accreditation. The survey of students received 96 responses, representing a wide range of experience, jobs, and backgrounds. We found that Plant ID classes that were required by "Range" programs had higher final quiz scores than classes that weren't required by a "Range" program ($\overline{x}$ = 86.0% and 78.3%, respectively). Similarly, classes that required a plant collection had lower average scores than classes that didn't require a plant collection ($\overline{x}$ = 76.3% and 82.1%, respectively), and classes that incorporated active learning activities daily had higher final quiz scores ($\overline{x}$ = 85.47%) than classes where active learning occurred only weekly ($\overline{x}$ = 75.6%). Plant ID classes in Range Management-related curricula are mostly well taught and incorporate multiple active learning methods. We suggest Plant ID classes continue to incorporate ample active learning methods, but that carefully selecting methods that keep student focus on Plant ID skills, rather than distracting from those skills, is important. Given the availability of Plant ID classes across multiple institutions in North America, future work could compare the outcome of different classes and sections using different teaching approaches.

Investigating Rangeland Systems and Practices: Enhancing Sustainable Agriculture Curriculum in South Dakota

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Abstract

The protection and preservation of rangelands is integral to key ecosystem services within the North Central Region such as biodiversity, recreation, and food and fiber production. Educating youth through a sustainable agriculture curriculum can serve as the direct link to the future sustainability of rangelands in the Great Plains and South Dakota. This project is focused on educating youth in grades 6, 7, and 8 about sustainable agriculture through a lens of rangeland systems and practices. Our overall objectives are to promote sustainable agriculture curriculum through educational events for teachers and 4-H Youth Program Advisors, have educators and youth learn about sustainable agriculture through a rangeland lens, and allow ranchers opportunities to connect and communicate with youth about their challenges, management practices, livelihood, and community impact. All lessons and laboratory/field exercises involve active learning strategies, such as think-pair-shares and small group discussions, as well as experiential and hands-on learning, using case studies developed by ranchers highlighting challenges they encounter. Ranchers are directly involved in this project through the “Adopt-a-Rancher” component, where they will provide vlogs (video blogging) to classrooms and help develop field trips to their ranches. Students and educators will learn about the local, national, and worldwide impacts sustainable agriculture has on people, the economy, and the protection of natural resources. This ongoing project will result in increased awareness of sustainable agriculture among youth, including challenges faced, impacts of management strategies, and career opportunities. After its completion in 2023, this project will have provided youth and, consequently, their families an objective understanding of what farmers and ranchers are doing, making them informed citizens and cognizant neighbors and future voters.

Building an Interactive Pedagogy in an Emergency On-Line Educational Environment: Taking the Opportunity to Creatively Rethink Meeting Educational Objectives

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Abstract

In the emergency rush to on-line learning in spring 2020, the goal was to meet learning objectives as designed for a face-to-face (f2f) course. While meeting programmatic learning objectives is essential, designs for f2f environment cannot always be satisfactorily recreated in an on-line environment. Shift to on-line learning is an opportunity to leverage that environment using different modes to meet learning objectives such as bringing in experts and virtual field trips. Rural landscape of many range program students presents some unique challenges: lack of high-speed internet infrastructure, limited computer infrastructure to accommodate video and multiple applications, change in work schedule to meet financial demands, and profound isolation impacting mental health. All of these challenges suggest that asynchronous options may benefit the student population. Voluntary on-line students are a different population than those students who are enrolled in a f2f program that went on-line under pandemic conditions. Students who choose the on-line environment may have more "self-starter" skills than students who move from a f2f environment. Building skills for a remote education environment are soft-skills that translate professionally. A subset of students stop participating in a course; promoting multiple forms of engagement is essential. To meet all of these goals, a flipped class where reading, watching lectures and discussion happen outside of class and in-class (synchronous) time is used for discussion, working through examples and applying knowledge in an interactive environment. Interaction continues on discussion boards and collaborative white boards engaging asynchronous students. Tools and approaches for engagement include: use of short, recorded lectures with embedded quizzes (e.g., Vidgrid), interactive polling, recorded for later viewing (e.g., Zoom quizzes, poll anywhere), interactive whiteboard collaborations (e.g., miro) and building deep-reading skills of technical information in an interactive discussion (e.g., Perusall). Sharing of student work (without grades) can also encourage engagement and build

Remote Delivery of Field Experiences in Soil Sciences - the Good, the Bad, and the Reality We're In

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Abstract

The COVID-19 pandemic placed unprecedented pressure on students and educators around the world, calling for a major shift in the delivery of educational lessons to implement remote learning opportunities in place of in-person classes. The shift to remote learning practices was particularly difficult for courses, such as pedology, that rely heavily on place-based or active learning strategies. In this study, the authors investigate student response to remote delivery of field experiences during the COVID-19 pandemic in an upper division Pedology course that is typically taught in-person and outdoors. Five field practicums were delivered remotely throughout the semester, where students were provided with a take-home field kit, soils from four profiles, and access to online resources needed to complete each assignment. Student perceptions on the efficacy of, value of, and engagement with remote delivery were assessed via pre- and post-surveys. Survey responses suggest that students' level of experience improved over the course of the semester and perceptions on the efficacy of, value of, and engagement with remote learning showed positive improvement. Although the majority of students were grateful for these alternative experiences, open-responses also expressed that remote delivery options are not favored over in-person field experiences. Remote delivery of field experiences also presents a potential solution to the limits in accessibility inherent to field-based courses.

Agricultural Undergraduate Students' Perception of Remote Learning: Survey Results from Six Land Grant Universities

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Abstract

The COVID-19 pandemic sparked the rapid transition of 1.9 million university students from in-person to remote learning in the Spring of 2020. The popular press and recent research reports highlighted serious challenges many students faced during this time. Yet, some students had a good or even very good experience with remote learning. The purpose of this paper is to compare student perspectives of their remote learning experiences in the early phase of the pandemic. We surveyed students across Colleges of Agriculture at six Land-Grant universities, generating a sample of 2690 completed responses. Students described their academic experience; learning environments (living situations, internet access, etc.); health, safety and family concerns; emotional stressors; and their Fall 2020 re-enrollment decisions. We find that prior online experience and differences in the student learning environment explain observed differences in learning experiences. Surprisingly, students identifying as female and students with children report a better overall class learning experience during the first month of the pandemic. Opportunities for active student engagement, reflective assignments, interaction with peers, and whether students felt that they gained knowledge all contributed to a more positive experience in a specific course. These results provide insights to instructors and have potential to inform instructional design and university policy.

Range Docs: A New Library for Key Rangelands Technical Documents

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Abstract

Successful rangeland management rests in the hands of well-informed land managers. When producers, conservation planners, and other stakeholders can quickly locate and access relevant information, they can make better decisions. The development of systems to organize and deliver knowledge to support adaptive rangeland management has been identified as one of the grand challenges to maintaining resilient rangeland systems. Organization of such information systems, however, is hindered by the distributed nature of resources across the internet and the lack of consistent and efficient search platforms. Topic-specific portals like GlobalRangelands.org (now RangelandsGateway.org) aggregate resources from disparate sources, but a standard vocabulary and directed tagging of resources is needed to improve relevance of search results. To meet the grand challenge of delivering accurate, relevant, and timely information to grazing land professionals, we developed Range Docs as part of the new Rangelands Gateway portal as a new approach to efficiently discovering, locating, and saving handbooks, technical notes, and other reference materials. Three key features set Range Docs apart from other document search sites: 1) it is built on a rangeland-specific thesaurus of terms harmonized from multiple sources such as the SRM Glossary and the NRCS Range and Pasture Handbook, 2) it contains the most relevant and useful resources as identified by agency staff and Extension specialists across the western US, and 3) it leverages paragraph-level annotations of core rangeland management concepts to get users quickly to the most relevant information they are searching for. The Range Docs project is led by the University of Idaho and University of Arizona in cooperation with the Rangelands Partnership, a collaborative of range extension professionals and librarians from 19 states in the western US. Workshops are being planned for 2021 to introduce the Range Docs to producers, land management agencies and technical service providers.

Counting M&Ms – A Delicious Way to Teach Natural Resource Monitoring and Vegetation Measurement.

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Abstract

Natural resource monitoring is a foundational skill needed for adaptive rangeland management. Therefore, nearly all natural resource degree programs include a course on measuring and monitoring vegetation. Many of these classes emphasize field experiences in collecting, analyzing, and interpreting various vegetation attributes. Our experience in teaching natural resource monitoring classes has confirmed that students and professionals engaged in continuing education can usually learn how to calculate indicators from field observations without much strife. However, most of these learners fail to grasp why indicators are calculated as they are or how different factors may influence these estimates. To address this challenge in meeting learning objectives, we developed a series of in-class exercises using chocolate candies (M&Ms) to illustrate different monitoring techniques and indicator calculations. For example, we designed simple modules to calculate frequency, density, cover, composition and biomass indicators and explore factors that influence indicator values. Advancing understanding of estimation can be gained by comparing populations of M&Ms, quantifying change over time and comparing variance among samples of M&Ms. We offer examples to foster understanding of vegetation assessment and monitoring with these easily defined and edible samples. A well-defined learning principle is that the acquisition of knowledge is increased with interest and engagement of the learner. And, what better way to increase engagement than chocolate? In fact, M&Ms have long been used to help students learn basic concepts in science and math. This effective pedagogy is finally reaching natural resources education to improve students' understanding of natural resource monitoring theory.

Adoption of Digital Learning Tools in Field-Based Natural Resource Courses

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Abstract

The 2020 academic year has been a period of growth and innovation range management pedagogy. Shifting to online, web-broadcast, and smaller face-to-face course formats necessitated the rapid adoption of new digital learning tools. Evaluating the effectiveness of these tools is critical in the natural resource fields where students traditionally learn planning and monitoring skills through face-to-face practicums and group activities.

During fall semester (2020), I adopted new teaching and assessment methods in three field-based courses; Range Plant ID (4950), Wildland Field Techniques (2400), and Natural Resource Career Orientation Seminar (2000). Digital communication technologies included; asynchronous (i.e. pre-recorded) video tutorials using Kaltura and Canvas, and synchronous (i.e live stream) lectures and group activities using Zoom.

Qualitative student course evaluations and pre- post-knowledge surveys were used to asses student perceptions and learning outcomes. Students responded positively to pre-recorded tutorials, but were less likely to watch videos before class unless it was part of a graded assignment. Students' response to web-broadcast zoom lectures varied among and within courses. Students were more engaged when breakout rooms, polls, or live chat were used 2-3 times per lecture period. Face-to-face lab exercises were preferred by all students at the beginning of the semester but near the end of the semester approximately half of the students opted to attend via web-broadcast. Overall digital learning tools accomplished learning objectives but required additional instructor prep time. Although remote learning options were not able to replace hands on lab experiences, pre-recorded tutorials and breakout rooms increased the efficiency of scheduled class time. The rapid adoption of digital teaching tools in 2020 advanced natural resource pedagogy. As the new normal manifests, remote learning tools and methods will continue to complement traditional hands on learning experiences.

New Assignment for Novel Learning Environments

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Abstract

To address some of the challenges of the past year of teaching new assignments had to be created for a pseudo-blended learning environment. I will present one such assignment that included the following objectives: 1) Students must be required to synthesize new knowledge of soil science using their own terms 2) Students will spend enough time on the assignment to align with NSCS board policy 3) Assignments must be able to be graded rapidly. The assignment I created to meet the above objectives was a weekly writing assignment that included some very specific criteria and provided prompts. Some of the basic criteria such as formatting were in place to assure students submitted enough written work to allow for compliance with board policy. Other criteria were established that constrained students' written work to the provided prompts and to limited them from taking common off ramps to fill space. Forbidden topics for students to include in their written work were family, money, health, politics, sex, sports, or religion. As expected, this was challenging for some. To meet the third objective the assessment of student work was based on three criteria. One, did the student submit their assignment on time? Two, did the students address the provided prompt? Three, did the student avoid all forbidden topics. This meant assessment consisted of reading the students submission and very little else, meeting the third objective. The weekly writing assignments were assigned to a sophomore level Principles of Soil Science at Chadron State College (CSC). This course is traditionally a high "D, F, W" course at CSC. To assess the effectiveness of this assignment I compared final exam scores, final grade distributions, and student evaluations. Results indicate that while students were challenged by the weekly writing assignments their understanding of soil science was improved.

Range Curricula Inspired by Place-Based Learning Communities and Generous Guest Speakers

Susan Edinger Marshall

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Abstract

Students from both introductory classes to culminating experiences need to connect to tangible and contrasting rangeland ecosystems. Covid-19 restrictions, too few faculty members, and content-intense courses, further challenge instructional effectiveness. In this presentation, I will share ideas from Humboldt State University's Place Based Learning Communities, scaffolding of content using progressively developed virtual posters, indigenous perspectives, and active learning strategies paired with guest speakers. I will also reflect on the design and management of supportive student working groups. While there is no substitute for authentic field-based learning experiences, we benefit by reaching out to our colleagues across the miles to bring diverse, authentic perspectives to our classrooms.

Range Livestock Production

Virtual Fencing for Precision Grazing Management

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Abstract

On public land grazing allotments in the sagebrush steppe, cattle are generally removed from burned pastures for a period of 2-years post-fire. If only a portion of a pasture burns, the burned area may be fenced, allowing for cattle grazing to resume in the unburned portion. However, traditional wire-based fencing is often not an option due to expense, conflicts with wildlife management objectives, and extensive procedural logistics on public lands. We evaluated the use of a "virtual fence" (VF) for excluding cattle from burned areas within small pastures in the sagebrush steppe of southeast Oregon. VF technology (Vence Corporation) uses GPS-based collars that direct animal movement within user-defined polygons using auditory and electrical ques. We burned 0.6-ha areas within six adjacent 2.1-ha pastures in a Wyoming big sagebrush-dominated plant community in the fall of 2019. In June of 2020, pastures were each stocked with 3 mature dry cows for 14-days. All cows were fitted with VF collars; collars were set to create a virtual fence around the burned area within 3 of the pastures (VF treatment) and remaining pastures had electrical and auditory cues turned off (control treatment). Collars recorded animal locations every 5 minutes. Cows in the control treatment initially spent up to 40% of their time within the burned area but use declined over trial day; forage utilization of the burned area was nearly 70%. Cows in the VF treatment spent approximately 4% of their time in the burned area on day one and were recorded in the burn only incidentally thereafter; forage utilization in the burn was < 3%. Our trial suggests VF technology is effective in controlling rangeland cattle movements and can severely curtail or eliminate use of burned areas. Additional work is needed to evaluate VF technology in larger rangeland settings.

Grazing Patterns, Diet Quality, and Performance of Cow-Calf Pairs Grazing Growing Season Shortgrass Prairie in the Texas Panhandle Using Continuous or High Stocking Density Grazing.

Larry Fritzler, Tim Steffens, David Lust, Marty Rhoades, Kathryn Vanderburg

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Abstract

This study quantified and compared differences in 1) defoliation patterns relative to water proximity; and 2) diet quality and performance of cow-calf pairs on Texas Panhandle native rangeland when cattle were continuously (CG) or rotationally grazed (HSD). Eighty cow-calf pairs were weighed and randomly allotted to treatment groups among paired replicate pastures of equal size dominated by blue grama (*Chondrosum gracilis* Willd.), and gummy lovegrass (*Eragrostis curtipedicellata* Buckley). HSD cattle were moved weekly over a 112 day grazing season at the same stocking rate and stocking intensity as CG using temporary fencing. Botanical composition and production were measured before and after the study to determine forage disappearance by species. Defoliation intensity patterns for individual plants were measured every 16 days using point transects out to 386 meters from water points. Gummy lovegrass biomass was lower ($p<0.05$) at the end of the grazing season in HSD than CG. Standing biomass and composition of cool season grasses were lower ($p<0.05$) at the end of the study in CG than HSD. Defoliation intensity within 386 m of water (y intercept of the regression line predicting defoliation probability) was higher ($p<0.05$) in period 1 and lower in periods 5, 6, and 7 ($p<0.05$) for CG. Cattle in CG maintained higher ($p<0.05$) dietary DOM and CP levels despite no differences in whole-plant TDN and CP levels of major species (blue grama and gummy lovegrass). No differences in animal performance between groups were noted. Warm season species composition and winter diet quality may improve over time under HSD grazing compared to CG, when stocking intensity of both strategies is the same.

Can Early Weaning Calves of First-Calf Heifers Improve Long-Term Herd and Financial Performance in a Vertically-Integrated Beef Production System? A Case-Study Application Using System Dynamics

Jase Taylor[1,2], Randy Stanko[1,3], Ryan Rhoades[4], Kimberly McCuistion[5,2], Clay Mathis[1,2], Rick Machen[1,2], Benjamin Turner[1,2]

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Abstract

Managing integrated beef production systems poses unique challenges not faced by managers operating in only cow-calf, stocker, or feedyard segments of the beef supply chain. Due to system-level feedback between components, problems in any one segment will have unintended consequences on the other segments. Here, we examine an integrated beef production system whose cow-calf segment has been challenged to maintain livestock reproductive performance (RP, i.e., the ability to produce a calf and be re-bred in time to remain on annual production cycles). We hypothesized that early weaning (EW) calves from first-calf replacement heifers (RH) would improve RP, resulting in a greater calf production and, by extension, profitability (for the cow-calf segment and the whole system). A system dynamics model was developed to evaluate conventional weaning (CW) versus EW of calves from RH and then tested based on EW in the first 21 or 42 days of the calving season. Results showed that the 21-day EW criteria would improve RP and financial returns marginally, but a 42-day criteria created significant RP and financial gains. Counterintuitively, these improvements did not arise in the cow-calf or feedyard segments (which saw financial performance reductions) but in stocker segment due to more efficient livestock gains facilitated by lower weaning weights of incoming calves. Sensitivity analyses revealed similar trade-offs between segments which may provide misleading feedback and mask changes that improve the whole system (e.g., EW reduced calf weaning weights and cow-calf profitability and reinforced the pressure on RP). Similarly, stocker segment gains due to EW could minimize long-term RP investments (e.g., improved pasture and forage quality) making the cow-calf level reliant on short-term livestock adjustments. Managing such trade-offs and avoiding the trap of thinking in silos requires a holistic mental model not currently rewarded by the incentive structure of the system.

The Stocker Steer Quandary: When to Market?

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Abstract

Land use of the semiarid Western Great Plains is characterized by livestock grazing. Yearling stockers provide both ecological and economic flexibility. In a typical year, these cattle graze from spring (mid-May) to fall (September/October). However, trade-offs exist between stocking rate (increased stocking typically decreases gains per-head but can increase gains per acre) and marketing date (given limited forage supplies, increasing stocking rate may imply a shorter grazing season due to increased herd demand). To address this complexity, we use historical price information from the Livestock Marketing Information Center (LMIC) and actual cattle weight from 2000-2019 collected at the USDA-ARS, Central Plains Experimental Range (CPER), in northeastern Colorado. We evaluate three stocking rate treatments implemented at CPER (Light, Moderate, and Heavy) with three marketing date options (early-August, early-September, and early-October) and estimate price distributions for observed month/weight class combinations. We analyze results over 100,000 random draws from these distributions to determine the possible net returns for each stocking rate/marketing date decision. Optimal solutions outperform the traditional management approach of early-October/Moderate. Accounting for the price-slide in Colorado, on average cattle net returns per head range from $92.69 for early-October/Heavy to $131.35 for early-August/Light. Returns per head are expected to be highest with Light treatments as these cattle typically achieve the highest gains over the grazing season. Cattle returns per hectare are highest with September/Heavy ($22.62) and lowest with September/Light ($12.52). We also analyze risk of each scenario. Increased risk associated with certain strategies (e.g. Heavy stocking yields the highest average net revenue per hectare for September, but also the largest potential loss) may influence producers' willingness to adopt those decisions. Revenue interactions with stocking rate should influence management decisions based on anticipated forage supply as well as other (e.g. ecological) management considerations.

Livestock Weight Gain Responses of Managing for Short Vegetation Structure in Shortgrass Steppe: Benefits of Adaptive Management?

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Abstract

Thick-billed longspur (*Rhynchophanes mccownii)* is a grassland bird species of concern in the shortgrass steppe which primarily nests in sparse, short-statured vegetation on loamy soils. Continuous, season-long grazing over multiple years provides this habitat, particularly with heavy stocking rates. However, with high stocking individual cattle weight gains are substantially reduced compared to those at moderate stocking. We evaluated cattle weight gains for an adaptive multi-paddock grazing strategy hypothesized to provide short vegetation structure while avoiding the low individual weight gains that occur with heavy, season-long stocking. Cattle in the adaptive treatment were managed at a moderate overall stocking rate with adaptive movements among ten, 130-ha paddocks that varied in soil and plant community types. The adaptive treatment involved grazing paddocks with loamy soils in midsummer to reduce vegetation structure and maintain longspur habitat. In 2019, livestock weight gains for the adaptive strategy with one large herd at high stock density (244 steers/130 ha) and moderate stocking rate were 0.980 kg/steer/day which were 2-6% lower than pastures season-long grazed at low densities (24-35 steers/130 ha), at either heavy or moderate stocking rates. During a drought year (2020), the adaptive strategy employed a medium stocking density (122 steers/130 ha) by splitting the large herd into two smaller ones. This resulted in weight gains (0.835 kg/steer/day) which were 86% and 17% greater than loamy pastures grazed season-long at low densities and heavy or moderate rates, respectively. Adaptive multi-paddock rotational grazing with medium rather than high stocking densities can enhance livestock weight gains in drought years by adaptively grazing sandy and mixed soil pastures in late spring and early fall, compared to season-long grazing at heavy rates on loamy pastures only. This strategy may also be able to maintain short-statured vegetation structure by intensively grazing loamy pastures for thick-billed longspurs.

Rangeland Cow Body Condition as Determined by FNIRS/Nutbal in the Edwards Plateau of Texas.

Douglas Tolleson[1], William Fox[2], Jay Angerer[2], Amelia Christian[2], Jose Diaz[1], William Pinchak[3]

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Abstract

The combination of fecal near infrared spectroscopy (FNIRS) and the Nutritional Balance Analyzer model (Nutbal) is an established method to monitor and manage grazing animal nutrition. However, users of FNIRS/Nutbal in the Edwards Plateau region of Texas have reported receiving unrealistically low (based on plant phenology, animal performance, etc…) predictions of cattle diet crude protein (CP) from currently applied U.S. - derived calibrations. We therefore evaluated the effectiveness of a west central Texas - derived FNIRS calibration for cattle diet CP along with a U.S. - derived calibration for cattle diet digestible organic matter (DOM) as inputs to Nutbal for predicting body condition score (BCS) of free-ranging beef cows in this region. BCS and composite fecal samples representing a herd of 26 mature (> 4-year-old; 476 ± 12 kg) cross-bred spring-calving beef cows grazing native rangeland pastures were collected monthly from April 2018 to September 2019. Nutbal inputs included FNIRS-predicted diet CP and DOM, pregnancy and lactation status, supplemental feed, and ambient temperature. Regression analysis determined relationships between observed and FNIRS/Nutbal-predicted BCS. In 2018, FNIRS-predicted diet CP ranged from a minimum of 7.05% (August) to a maximum of 9.69% (July). Similar values for DOM were 50.96% (December) and 59.08% (July). Observed BCS ranged from 4.0 ± 0.14 (April) to 5.2 ± 0.17 (December). In 2019, FNIRS-predicted diet CP ranged from 6.85% (September) to 12.01% (May). Similar values for DOM were 52.00% (January) and 59.77% (June). Observed BCS ranged from 3.7 ± 0.09 (September) to 5.3 ± 0.18 (January). There was a significant ($P < 0.0004$; $r^2 = 0.61$; SE = 0.40) positive relationship between observed (4.65 ± 0.10) and FNIRS/Nutbal-predicted (4.56 ± 0.15) BCS. Predicted BCS was within 0.5 of observed BCS 81% of the time. Cattle diet quality and performance were predicted with enough accuracy to inform management decisions.

Landscape Use of Angus Crossbred vs. Raramuri Criollo Cattle on Desert Rangeland

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Abstract

We conducted a replicated study (in both space and time) to validate previous findings reporting differences in grazing patterns of Raramuri Criollo (RC, heritage breed) vs. Angus Hereford crossbred (AH, commercial breed) cows grazing Chihuahuan Desert rangeland. We monitored cows of both breeds that grazed desert pastures separately during summer and winter in three consecutive years. GPS positions were acquired from 5 to 11 randomly selected cows of each breed and were classified based on movement velocity. Presumed grazing locations were used to calculate Ivlev's electivity index to determine preference (E>0) or avoidance (E<0) of pixels relative to thirteen pasture attributes including topography, vegetation, facilities, temperature, and moisture variables. Statistical mixed models were used to determine the effects of breed and season on selection of pixels. Separate analyses were conducted for each pasture attribute. Both breeds avoided areas far from water, but RC cows showed higher preference for pixels close to the drinker during the dormant season. RC cows appeared to exhibit a keener ability to select pixels with differing surface temperature, and greenness compared to AH counterparts. RC cows showed greater preference for pixels with high shrub density than AH counterparts in summer. During the dormant season, both breeds preferred sites with high shrub density. AH cows exhibited a strong preference for black grama pixels and higher avoidance of pixels with high density of other grasses. RC cows, did not select pixels with high black grama cover. Average electivity values for each pixel (grazing likelihood) revealed remarkable season differences between breeds. In summer, both breeds appeared to prefer similar portions of the pasture, whereas in winter, pixel preference (and hence spatial distribution) of breeds diverged significantly. Our study confirmed previously reported differences in landscape use patterns of RC vs. AH beef cattle.

Dam-Offspring Pairing Using Proximity Loggers Fitted on Raramuri Criollo Cows and Calves Grazing Desert Rangeland

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Abstract

Proximity loggers are sensors that transmit and receive UHF radio signals and have been used to investigate social behavior in livestock. Previous studies that used these devices found that cow-calf contact events occur throughout the day at intervals that likely reflect nursing events. We determined the feasibility of utilizing proximity data to correctly identify cow-calf pairs within a herd of Raramuri Criollo cattle grazing Chihuahuan Desert rangeland. The study was conducted at the Jornada Experimental Range on a 4300 ha pasture that was lightly stocked (216 ha/AUM). Ten proximity loggers were deployed on five cow-calf pairs during the summer/fall of 2015 and 2016 (21days/deployment). All calves were <2 weeks old at the onset of the study. The loggers recorded time of initiation and duration of contacts any time another logger was within a one-meter radius of the subject. We used one-way analysis of variance to analyze daily contact duration patterns between each collared cow and all collared calves in the herd. Except for one cow in the herd (Dam25), all dams spent significantly more time within 1 m of their offspring vs. other collared calves in the herd ($P<0.05$). Proximity logger data yielded cow-calf pairings that were 100% accurate. Newer less expensive technology such as Bluetooth-enabled wearable livestock sensors offers opportunities to track cow-calf contact patterns in real time and could help ranchers identify dam-offspring pairs using the analytical approach followed in this study. This approach could be particularly useful for rangeland cow-calf producers that run seedstock operations.

The Importance of Proper Vitamin and Mineral Supplementation of Beef Cattle on Rangeland

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Abstract

Through work done by Dr. Hall and the rest of his team at the Utah Veterinary Diagnostic Laboratory in Logan, Utah, it was found that when producers decrease or completely stop vitamin and mineral supplementation, there is an increase in vitamin-mineral deficiencies. These deficiencies can result in lower growth rates, poor immune system function, inadequate response to vaccinations, increased cases of infectious diseases, increased death losses, and lower reproductive performance in herds. Dr. Hall was working with two producers from Idaho that decided to split up a ranch. One producer felt a good mineral package was essential, and the other thought it was a waste of money. The rancher who thought a mineral package was essential had a 10% better breed back, and calf weights were 70 lbs. heavier.

Feeding Habits of Brangus and Raramuri Criollo Cows Grazing Chihuahuan Desert Rangeland

Danielle Duni[1], Andrés Cibils[1], Richard Estell[2], Andrew Cox[3], Sheri Spiegal[2]

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Abstract

Heritage cattle breeds may help improve sustainability of ranching in the arid Southwest. Foraging behavior of Raramuri Criollo (RC, heritage breed) and Brangus (BR) cows was observed to determine whether breeds differ in the amount of browse included in their diets. Cattle were monitored by a single observer who scan sampled groups of 3 to 16 animals at 30 second intervals for 30 minutes during morning and afternoon foraging bouts to determine frequency of grazing vs. browsing. To the best of the observer's ability cattle were undisturbed while monitoring. Observations were conducted on 29 or 23 days in spring and summer, respectively. A total of 5,824 (3,521 RC, 2,303 BR) and 7,120 (3,429 RC, 3,691 BR) in spring and summer, respectively, were summarized and analyzed. Analysis of Variance using PROC GLM in SAS 9.4 to determine the effect of breed and season on frequency of browsing and grazing of cattle in this study. LS means were compared using the Tukey-Kramer test. We found a significant breed-by-season interaction for browsing ($P< 0.01$) and grazing ($P< 0.01$) frequency, therefore breed differences in feeding habits depended on the season considered. In spring, RC cows were observed browsing more often (64.4 %; $P = 0.08$) and grazing less often (35.6%; $P = 0.08$) than BR cows (browsing: 29.7%; grazing: 70.3%). In summer, no differences between breeds were observed ($P > 0.10$). RC were observed browsing more often ($P=0.02$) and grazing less often ($P= 0.02$) in spring than in summer whereas BR showed no statistically detectable seasonal differences in grazing and browsing frequency ($P > 0.1$). Our results, while preliminary, suggest that relative to BR, heritage cows grazing Chihuahuan Desert rangeland include more browse in their diets during spring and exhibit higher seasonal plasticity of feeding habits.

Effect of Preconditioning Diet on Subsequent Juniper Consumption in Mature Female Goats.

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Abstract

Juniper species are invasive native plants that are increasing on many Texas rangelands. Juniper provides forage for browsers but does contain potentially toxic compounds. Goats have been used as a biological management tool for Juniper. We evaluated how feeding ground juniper as the roughage component of a mixed ration influences intake of fresh juniper foliage. Mature female approximately 2-year-old) Boer-Spanish-cross goats (*Capra hircus;* 32.7 ± 0.45 kg) were stratified by weight into groups fed either Diet 1 (n = 30) containing 12% CP with 20% cottonseed hulls as the roughage or Diet 2 (n = 30) containing 12% CP but with 20% ground juniper as a roughage. Goats were housed in 20 dirt-floor pens (n = 10 pens/diet) with shade and water (3 goats/pen). Goats had not previously been exposed to juniper. Following a 21-d preconditioning feeding period, there were no differences ($P > 0.10$) in BW (Diet 1, 35.9 ± 0.7 kg; Diet 2, 36.9 ± 0.6 kg). No differences were detected for DMI (Diet 1; 2,509 ± 42.6 g d^{-1}; Diet 2; 2,584 ± 47.6 g d^{-1}) of either group. Voluntary DMI of freshly harvested *Juniperus ashei* limbs and intact leaves in these goats for 21 d. Goat BW did not differ ($P > 0.10$) between groups after offering fresh juniper foliage (Diet 1; 39.1 ± 0.7 kg; Diet 2; 40.1 ± 0.7 kg). There were no differences ($P > 0.10$) between groups for juniper foliage DMI (37 ± 1 g kg BW^{-1} day^{-1}). Results indicated that preconditioning goats with ground juniper for 21 d did not create any negative health effects nor influence subsequent consumption of fresh juniper foliage. Further research on different age and sex class groups is needed.

The Interaction of Prenatal Stress and Translocation to an Unfamiliar Landscape on Grazing Behavior in Brahman Heifers

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Abstract

Stress experienced by the dam during gestation affects subsequent physiological functions in the offspring. Transportation is a stressor for livestock. Increasing climate variability (drought) may result in an increase in livestock being moved from “dry” to “wet” locations. The effects of prenatal transportation stress on offspring grazing behavior is unknown. We utilized 12 Brahman (*Bos indicus*) heifers (~12 mo, 300 kg); 6 from dams subjected to transportation stress during mid-gestation (PNS) and 6 from non-stressed dams (CON), in an effort to determine the interaction between prenatal stress and translocation to an unfamiliar landscape on grazing behavior. Heifers were moved from Overton Texas (32.3 N, 95.0 W; 1245 mm annual precipitation) to Sonora Texas (30.6 N, 100.6 W; 610 mm annual precipitation) in April, 2020. Each treatment group grazed a separate but adjoining 24-ha pasture during 2 experimental grazing periods (28 d). GPS location data were collected from 21 July 2020 to 18 August 2020. Distance from water, elevation, slope, distance traveled, and rate of travel data were collected every 10 min. Prior 90-day precipitation was 356 mm for Period 1 and 164 mm for Period 2. Dry matter standing crop ($P > 0.1$) was 1265 ± 138 and 1060 ± 199 kg/ha for the PNS and CON pastures respectively in mid-Period 1; 849 ± 137 and 1134 ± 180 kg/ha in mid-Period 2. No differences were detected between CON and PNS heifers for rate of travel, maximum distance spent from water, or slope and elevation utilization ($P>0.1$). On average, PNS heifers spent time 116 m further from water than CON ($P = 0.003$). In addition, PNS heifers tended to travel further per day,4264 m, when compared to CON heifers, 3377 m ($P =0.064$). Prenatal stress appeared to manifest in grazing behavior differences in these Brahman heifers.

The Grass Is Greener in the Burned Patch: Livestock Responses to Variable Forage Nutritive Value on Patch-Burn Grazing Pastures in North Dakota

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Abstract

Understanding how forage nutritive value varies within a pasture and in response to disturbances like fire and grazing provides insights into grazer selection and whether available forage meets the nutritional requirements of grazing livestock or whether supplementation is required. We measured spatial and temporal variability in forage nutritive value and investigated grazer distribution throughout the summer grazing season within pastures managed primarily with patch-burning over a four-year period in North Dakota. We clipped available forage at monthly intervals during the summer grazing season at points distributed amongst dominant ecological sites in each patch to compare production along the time since fire gradient and between ecological sites. We determined crude protein, acid detergent fiber, acid detergent lignin, and neutral detergent fiber using near-infrared spectroscopy (NIRS) with a custom calibration curve. We calculated total digestible nutrients from NIRS results. To determine grazer distribution, we counted fecal pats within 5-m of each forage sampling point at the time of sampling. Statistical analyses compared forage properties and grazer responses across patches and ecological sites. Both sheep and cattle preferred recently burned patches throughout the grazing seasons where forage had higher crude protein and lower fiber content. Attraction to the recently burned patches helps maintain patch contrast in biomass. More biomass in patches with increased time since fire serves as a grass-bank in the event of a drought, maintains fuel load for prescribed burns, and maintains structural heterogeneity within the pasture. The potential for patch-burning to ensure adequate forage availability and meet or exceed nutritional requirements throughout the summer grazing season might reduce management costs by limiting the need for protein and energy supplementation during this time.

Rangeland Habitat Diversity

Is Sagebrush for the Birds?

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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 in many areas due in part to anthropogenic and natural disturbances. In addition to greater sage-grouse, free-roaming horses invasively occupy sagebrush dominated landscapes and have been found to impact rangeland health and availability of natural resources. Free-roaming horse populations have exponentially increased since the passage of the Wild Free-Roaming Horses and Burros Act of 1971. The act protects horses on public lands and allows them to impact the ecosystem in a largely unmanaged way. We hope to identify if horse presence does or does not impact the abundance of greater sage-grouse, as a sagebrush obligate species. The objectives of this study include 1) quantifying sage-grouse lek attendance throughout specific areas in Utah and Nevada and relating trends to habitat conditions, and 2) determining the potential influence that feral horses, coupled with cattle grazing, have on sage-grouse abundance in the Great Basin. With detailed mapping of sage-grouse habitat and Herd Management Areas (HMAs) and field data collection, we hope to identify specific drivers of lek success or decline, keeping in mind a myriad of factors could be working together attributing to population decline. These data will be useful for horse and sage-grouse management to assess the potential impacts of free-roaming horses on sage-grouse habitat suitability. Additionally, these data will be helpful for wildlife management, specifically the BLM (as the entity endowed with the task of management of horse populations on public lands), because if horse presence is indeed found to be a driving factor in sage-grouse population decline, management restrictions may be required to protect the delicate sagebrush ecosystem.

A Grass Fly's [conioscinella Nuda (Diptera: Chloropidae)] Preference Among Four Native Warm-Season Grasses

Tim Springer

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Abstract

Adult flies of *Conioscinella nuda* (Adams) were collected from field plots of four native grass species, big bluestem (*Andropogon gerardii* Vitman), little bluestem [*Schizachyrium scoparium* (Michx.) Nash], sand bluestem (*A. hallii* Hack), and Indiangrass [*Sorghastrum nutans* (L.) Nash] to determine the insect's preference among these species. The mean number of insects varied from 9.7 to 27.0 adults per 15 plants, and the order of preference was big bluestem, little bluestem, sand bluestem, and Indiangrass. Differences occurred among plant species for *C. nuda* preference ($P < 0.05$) where, big and little bluestem were preferred over sand bluestem and Indiangrass ($P < 0.05$). The observed differences among the grass species may be related to spikelet hairs. The spikelets of big bluestem and little bluestem are mostly glabrous compared to those of sand bluestem and Indiangrass which are covered with conspicuous hairs. Host plant resistance may offer the best approach for controlling *C. nuda*.

Grazing System and Legacy Effects of Cultivation on Soil Microbial Diversity in the Canadian Prairie.

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Abstract

Cattle grazing and historical cultivation can affect soil microbial diversity through changes in vegetation and soil characteristics, which may impact ecosystem functioning and influence carbon and nitrogen cycling. However, little is known about how soil microbial diversity responds to different grazing systems on lands with historical cultivation, compared to those without, across the range of climatic conditions found within the Canadian prairies. The main objective of this project was to understand the effects of grazing management systems and cultivation history on soil microbial diversity. Soil samples were collected from 21 pasture pairs (Adaptive Multi-paddock (AMP) vs. conventional grazing (n-AMP)) having varied cultivation histories across Alberta, Saskatchewan and Manitoba, Canada. Bacterial, archaeal and fungal communities were quantified using qPCR and diversity was assessed via high-throughput sequencing of 16S rRNA and ITS genes. Alpha diversity of the fungal community was significantly higher in n-AMP ranches without prior cultivation compared to the other three treatments (AMP with and without cultivation and cultivated n-AMP) (P=0.021). This suggests these pastures (n-AMP, non-cultivated) may have improved ecosystem functioning because higher fungal richness enhances both functional redundancy and functional uniqueness within the community. In contrast, bacterial community diversity did not differ between grazing systems (P>0.05) but was affected by historical cultivation (P<0.05). Diversity of dominant taxa such as *Proteobacteria, Bacteroidetes*, *Planctomycetes*, *Actinobacteria* and *Acidobacteria* were higher in historically cultivated pastures (all $P \leq$ 0.042), while diversity of *Firmicutes* (P=0.04) and *Chlamydiae* (P=0.03) were lower. In summary, fungal community composition in northern temperate pastures was controlled by both grazing management and cultivation history, while bacterial communities were affected only by cultivation history.

The Biodiversity Attributes of Sandsage Prairie Rangelands

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Abstract

Sandsage prairie is a shrub-steppe ecological system of the Great Plains of North America in which sand sagebrush (*Artemisia filifolia*) is dominant and diagnostic. The total areal extent of sandsage prairie is estimated at five million hectares (12 million acres), but discontinuous distribution across the more remote and thinly-populated parts of eight different states masks the ecological significance of these rangelands. The dune fields that support sandsage prairie occur as regionally restricted physiographic islands within the larger landscape and have a biota distinct from that of surrounding habitats, including many regional endemics and ecological specialists. Forty-four plants and animals associated with sandsage prairie are of conservation concern at the global or state level. Sandsage prairie is particularly important to avian ecology in the Great Plains, with 14 species of endemic or obligate grassland birds utilizing sandsage prairie rangeland for breeding and/or foraging habitat. In many parts of its distribution, sandsage prairie is the only native vegetation of significant scale remaining on the landscape, providing islands of natural habitat critical to the support and persistence of biological diversity. These attributes make the sandsage prairie ecological system a biodiversity hotspot for the central and southern Great Plains. Maximizing the biodiversity values of sandsage prairie rangeland requires preventing further loss, fragmentation, and degradation of existing occurrences as well as accommodating or restoring processes that drive the inherent heterogeneity of this unique ecological system.

Landscape Prioritization for Bird-Friendly Ranching Using Hierarchical Models

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Abstract

Declines of bird populations breeding in North American rangelands are important and widespread, and implementing management that sustains rancher livelihoods while offering opportunities for wildlife could attenuate or reverse these trends. However, response of bird communities to management can vary across landscapes, and identifying areas with the greatest potential bird response is a pressing research need because time and other resources are limited. In northeast Wyoming, USA, Audubon Rockies is working with ranchers through the Conservation Ranching Initiative, a market-based approach to conservation that connects conservation-conscious consumers to rangelands managed with bird-friendly practices. To help prioritize this effort, we used bird surveys from 175 sites (2009−2018) conducted with the Integrated Monitoring in Bird Conservation Regions (IMBCR) protocol, and we fit a hierarchical community model to estimate bird distribution and abundance of multiple species while accounting for variation in detectability. We then created spatially-explicit predictions across the study area, identifying locations with potential for high bird abundance and richness where the Conservation Ranching Initiative could be prioritized. We also evaluated relationships with more fine-scale habitat components to infer potential management for each species. Finally, our framework established a baseline for continued monitoring as the Conservation Ranching Initiative is implemented across the landscape, which will clarify the link between consumer decisions and conservation outcomes.

Ecological Implications of Plant Secondary Metabolites - Phytochemical Diversity Can Enhance Agricultural Sustainability

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Abstract

Conventional agriculture production, although proficient in feeding an expanding human population, is having negative environmental impacts that are diminishing the sustainability of natural resources. Producers and consumers are increasingly interested in understanding how land management practices can enhance agricultural sustainability and improve human health. We discuss a new approach to enhancing agricultural sustainability by growing crops and forages with diverse plant secondary metabolites (PSMs). Plants produce tens of thousands of PSMs to mediate interactions with soil, other plants, and animals. Plants use these metabolites to communicate with organisms in their environment, both above and belowground, and to modify the rhizosphere and influence chemical, physical, and biological attributes of soil. In pastures and rangelands, animal health benefits and production increases when animals ingest forages with different PSMs, which has implications for enhancing the biochemical richness of meat and dairy products for human consumption. A deeper understanding of PSMs, and their functional roles in agroecology, may help producers better manage their lands, reduce inputs, and minimize negative environmental impacts.

Technology to Support Land Manager Decision-Making – Using the LandPKS "Habitat" Module to Improve Land Resilience and Wildlife Habitat

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Abstract

Grazinglands are essential to maintaining large connected natural landscapes and improving resilience through compatible management. Native plants and animals require a wide range of habitats across space and time. Creating a patchwork of habitat conditions by varying grazing intensity can improve native species diversity and support resilient and productive land for wildlife and livestock. Through the free, open-source app LandPKS, managers can access localized information about their land and understand how the habitat available contributes to the broader landscape.

The new "Habitat" module in LandPKS currently includes 22 North American species, including birds, mammals, reptiles, insects, and a plant. The project team selected the initial set of species based on their occurrence in the Great Plains and Great Basin, and for which habitat is a limiting factor, and grazing management can influence habitat quality and quantity. The LandPKS "Habitat" module provides science-based habitat information that can be used to develop ranch goals, guide management actions, and create monitoring plans. Based on plot location, the app displays species that may occur in the area and includes a table summarizing habitat requirements. Any soil and vegetation data collected by the user at the location also shows in the table. Factsheets offer more information, including identifying the species, ideal habitat, and tangible actions a landowner might take to improve habitat for the species.

A story map will demonstrate the habitat module's functionality and how ranchers and other land managers can use the information to modify land management and find supporting materials on the LandPKS website.

Maintaining Rangeland Productivity while Protecting Rare Native Prairies in Western WA

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Abstract

Most rangelands west of the Cascades in the Pacific Northwest occur on sites that historically supported native prairie. Over 90% of these prairies have been converted to agriculture or lost to development, making conservation of this rare ecosystem a top priority. Effective conservation of remnant native prairie ecosystems will require identifying opportunities for ranchers to increase the conservation value of their properties while maintaining or enhancing their bottom line. We evaluated grazed and ungrazed prairie sites to quantify the conservation value generated by conservation grazing practices (CGP) including spring grazing deferments, rotational grazing regimes, and seeding native plant species. On three working ranches, replicated 1-acre plots that received the CGP were compared to 'business as usual' (BAU) plots and to three native upland prairie (NUP) preserves. Native and non-native species richness and diversity, forage productivity, gopher activity, and soil parameters were evaluated using combinations of paired 15m x 15m subplots and grazing exclusion cages within the treatments. Native richness significantly increased within CGP treatments over 2018-2019 ($p<0.001$), but native species richness at ranch sites was still much lower than native ungrazed prairies (2-10 species on average at ranch sites compared to 15-21 species on average in NUPs). The proportion of plots with gopher activity was not significantly different across treatments, and the greatest year-to-year increases occurred at ranch sites. Forage production was not negatively affected by CGP treatments and tended to increase under rotational grazing. Average daily high soil temperature was significantly lower under CGPs, indicating enhanced conditions for forage productivity. These preliminary results indicate that when conservation grazing practices are implemented, working prairies can provide conservation value for key native species while maintaining forage productivity for ranchers. In the future, working lands may be eligible for mitigation credits associated with habitat preservation for endangered species protection.

Time Since Fire and Livestock Species Influence Butterfly Populations in Post-Conservation Reserve Program Landscapes

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Abstract

Global pollinator declines represent a major threat to future food security. Habitat destruction and fragmentation in combination with mismanagement and pesticide use are all contributing factors. Conservation Reserve Program (CRP) plantings have been important in reestablishing perennial cover and can support pollinators in United States regions where native grasslands have been lost. However, as recent contracts have expired, many landowners have decided not to reenroll in the program and instead allocate the land for different uses. We evaluated the influence of grazing post-CRP landscapes with cattle or sheep within a patch-burn grazing framework on grassland butterfly communities. Specifically, we examined the effect of time-since-fire and livestock species (sheep or cattle) on butterfly abundance and diversity at the Hettinger Research Extension Center (HREC) in Hettinger, ND. We used line transect distance sampling (LTDS) across 72 transects in 6 pastures (3 sheep and 3 cattle-grazed). Surveys were repeated 3 times yearly (June-August) for 4 years (2017-2020). We observed 15,982 individual butterflies composed of 29 species across all sites, with cattle pastures boasting significantly more species and individuals than sheep pastures. Selection ratios for the 6 most commonly observed butterfly species indicated differing monthly trends. However overall, 3 species selected for patches burned that season and 1 species each selected for 1 year, 3 years, and never previously burned patches. Our results indicate that patch-burn grazing promotes greater butterfly abundance and diversity across the landscape than traditionally homogeneous management practices and suggests that restoring natural disturbances to post-CRP fields can provide resources for grassland butterfly communities. This study demonstrates that converting CRP lands into working landscapes after contracts expire has the potential to provide a conservation-friendly alternative to row-crop implementation, decreasing fragmentation and improving biodiversity overall by providing habitat for many grassland species.

Shelterbelt Use and its Effect on Honey Bee Colony Health in the Northern Great Plains

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Abstract

Globally, pollinators are experiencing broad-scale population declines, causing a reduction in available pollination services. Pollinator losses are a result of multiple drivers, including habitat loss, pesticide use, and diseases, impacting both native bees and managed honey bees. This is particularly concerning in the Northern Great Plains of the United States, the leading region for honey production, where early-season food resources are critical for the honey bee industry. Early flowering trees and shrubs planted within shelterbelts, tree plantings installed as windbreaks for soil retention, may provide essential resources to fill these forage gaps throughout the Northern Great Plains. However, there has been little research related to early-season forage and the utilization of these shelterbelts by honey bees. We examined the influence of nearby shelterbelts on honey bee colony health. Using hive scales, we monitored honey bee colony weights (as a proxy for colony health and honey production) throughout a growing season. We selected apiaries within landscapes across a gradient of low to high shelterbelt densities in two regions of the Dakotas (western and central). Each colony's daily and seasonal weight data will be used to assess the importance of both the composition of and distance to anthropogenically-planted trees and shrubs. For the 2020 field season, we used 48 colonies between May and September at apiaries that varied in nearby tree cover and collected hourly hive weights for each colony. We expect colonies near high-density and diverse tree plantings will display significant weight gain trends over time relative to colonies in apiaries located further from tree plantings. Our results will explain trends in honey bee colony health and honey production across a gradient of landscapes, which will help influence future apiary management in landscapes with an early-season forage dearth.

Are All Floral Resources Equal? Characterizing the Bee Communities Utilizing Exotic Floral Resources in the Northern Great Plains

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Abstract

Many grasslands in the Northern Great Plains are considered novel ecosystems created by the prevalence of exotic plant species and their interactions with the existing ecosystem. Among these new interactions are the ones between exotic forbs and pollinator communities. Exotic forbs, especially those with invasive tendencies, often occur at high densities which could potentially be attractive to bees. However, some native bees may not prefer or be able to utilize pollen from exotic forbs due to diet or other life-history constraints. Our objective was to determine which bees, based on taxonomic and functional trait groupings, utilize exotic floral resources. Our data was sourced from 636 net surveys performed at 53 grassland sites across North Dakota from 2017-2019. At each survey, observers would capture bees on flowers within a 50-m^2 plot for 30 minutes and record the plant species bees were captured on. Observers counted flowering stems by species in a belt transect to estimate floral resource density. We categorized bee species into broader taxonomic groupings and functional traits based on diet breadth, sociality, and body size. We recorded 966 interactions between 82 bee species and 68 plant species. Our analyses will explore relationships between bee abundance, richness, and diversity between native and exotic plants, and will compare the proportions of bees within each taxonomic and functional trait grouping captured on each plant type. Using density estimates from floral belt surveys, we will display regression slopes of bee diversity measures against increasing native and exotic floral densities. Determining whether there are imbalances in the types of bees that visit exotic floral resources will improve our understanding of how exotic plants shape native communities.

Promoting Aspen Recruitment via Livestock Reduction is Contingent on Wild Ungulate Presence in Semi-Arid Rangelands

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Abstract

Browsing by domestic ungulates is frequently cited as a driver of reduced recruitment in quaking aspen (*Populus tremuloides*), a widely distributed tree species that provides critical habitat and forage for wildlife, especially in drylands. To promote aspen recruitment, land managers often erect exclosures to protect young aspen from livestock browsing. Despite their high monetary and labor costs, the effectiveness of livestock exclosures in increasing aspen recruitment in the arid margins of aspen's range remains unknown. We sampled aspen stands in 36 livestock exclosures and 43 nearby control (unfenced) plots in the Great Basin and southern Cascades and found that the effects of livestock reduction on aspen recruitment varied relative to local herbivore guilds. Livestock exclosures were found to effectively reduce browsing and increase recruitment of aspen where wild ungulate populations were low, but had very little effect on browsing intensity and recruitment in areas where wild ungulate populations were high. Furthermore, reduced livestock browsing within exclosures resulted in significant shifts in understory plant community composition in aspen stands. Exclosures were associated with higher cover of native perennial grasses and shrubs but lower cover of native forbs relative to control plots. In the Great Basin, the cover of cheatgrass (*Bromus tectorum*) was significantly higher in exclosures relative to controls sites. Collectively, these finding indicate that managers should consider local herbivore guilds, the presence or absence of invasive annual grasses, and specific understory vegetation management goals when determining whether livestock exclosures are an appropriate tool for aspen management.

Linking Plant, Insect, and Bird Responses to Grazing on Conservation Reserve Program Grasslands

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Abstract

The Conservation Reserve Program (CRP) has contributed to the large-scale restoration of perennial vegetation from former cropland across the United States. Although nearly 23 million acres are currently enrolled in the CRP, few studies have examined the trophic responses of wildlife to management on these restored habitats across large spatial scales. We addressed this gap by surveying plant, insect, and bird communities on 108 CRP fields across a 635-mm longitudinal precipitation gradient in Kansas. Study fields were split between two Conservation Practices (CP) with lower (CP2) and higher (CP25) diversity seeding mixes, and approximately half (53) of all fields were grazed by cattle over two growing seasons. We predicted that the plant community would respond directly to CP and grazing treatments, insect biomass would respond to CP and grazing through changes in the plant community, and the bird community would be predicted largely by changes in the physical structure of the plant community and secondarily by insect biomass. Though CP did not impact plant community responses, grazing reduced plant biomass, litter depth, and plant height, and increased variability in plant height. Insect biomass was positively related to increasing forb cover and variability in plant height but negatively to increasing litter depth. Longitude was the only significant predictor of bird species richness, while bird species evenness was negatively related to increasing plant height and positively with more grassland within 1 km of a given CRP field. Altogether, we found evidence for cascading direct and indirect relationships between grazing, the plant community, insect biomass, and the bird community, but not a direct link between insect and bird responses. Our results suggest that grassland bird communities may not be food-limited as expected. Further fine-scale sampling will help elucidate this trophic relationship and predict the response of these taxa to management on CRP lands.

Comparing Floral Resources between Native Prairie and Seeded Old Fields on the Pacific Northwest Bunchgrass Prairie

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Abstract

Agricultural development, both past and present, has fragmented grasslands worldwide leaving gradations of habitat ranging from active crop production, old fields, semi-natural grasslands, and seeded pastures to native remnants. Degradation and fragmentation of grasslands are linked to global declines in native pollinators through variation in floral resources found on this habitat continuum. Pollinators depend on floral resources for survival and can benefit from species-rich plant communities that bloom throughout the growing season. Forb communities are known to be limited in old fields but little is known about how reseeding these old fields with introduced forage grasses impacts floral resources, especially on the threatened Pacific Northwest Bunchgrass Prairie (PNB). This study addressed the following questions: 1) How do forb abundance, richness, diversity, and community composition differ between native prairie and seeded old fields through growing seasons? 2) Are there indicator species for the two land treatment types, growing seasons, and sampling years? and 3) How do floral resources differ over two growing seasons and between sampling years? We found floral resource abundance, richness, and diversity were significantly lower in seeded old fields than in native PNB sites. This legacy was evident throughout the growing seasons in both sampling years. Floral resources decreased in both habitat types over the growing season but were consistently lower in seeded old fields. Indicator forb species for native prairie and seeded old fields were related to their reproductive modes and seed dispersal. Our findings underscore the differences between floral resources on native grasslands and the gradations of habitat that remain. Specifically, it highlights that rhizomatous forage grasses continue to dominate seeded old fields and provide less floral resource abundance, richness, and diversity than native prairie sites. Active restoration may be necessary to improve pollinator habitat on seeded old fields, especially for late season floral resources.

Topographic Effects on the Spatial and Temporal Variability of Seedbed Microclimate: Potential Contributions to Resistance and Resilience.

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Abstract

Ecological resilience and resistance to disturbance of native and seeded-non-native plant communities in the Great Basin appear to follow topographic patterns associated with slope, aspect and elevation. Current resistance and resilience concepts are based on concepts of soil-climate classification. We hypothesized that probabilistic patterns of shorter-term weather effects on seedbed microclimate might also contribute to perceived patterns of resistance and resilience as a function of topography. We used a 41-year gridded weather dataset and the Simultaneous Heat and Water (SHAW) model to estimate seedbed temperature and water potential at seeding depth as a function of slope, aspect, elevation and soil type in the 20,000 ha Boise Front Management Area. Hydrothermal germination-response models were then used to generate indices of seedbed favorability for initial germination and emergence, and to estimate cumulative germination response as a function of topography and planting date. We used these simulations as a bioassay to assess spatial and temporal variability in seedbed microclimate as a function of slope and aspect, and to assess potential planting date effects on germination and emergence as a function of topographic position and elevation. Topographic mapping of seedbed favorability showed distinct patterns associated with both slope and aspect and may provide additional metrics for estimating a seedling-establishment component of ecological resilience and resistance over space.

Reproduction of Ecotypes of Kochia Prostrata with the Use of Biotechnologically Active Products

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Abstract

Kochia prostrata is a semi-shrub from the Chenopdiaceae family, 60-90 cm high. Kochia is an ecologically plastic plant. It develops deep-penetrating (up to 5-6 m) root system of a universal type, uses the moisture of a large volume of soil. Productive longevity is 15-20 years.

Kochia prostrata var. *canences* ecotype can be cultivated on sandy loam and loamy soils of the foothills. In culture, it bears seeds in the first year of life. The yield of dry fodder mass is 1.10-1.40 t/ha. The seed yield of this ecotype is 120-160 kg/ha.

The *Kochia prostrata* var. *virescens* ecotype is suitable for cultivation on loamy and sandy loam soils of the foothill and wormwood - ephemeral desert. The seed yield is about 150 - 160 kg/ha. It is well eaten by all types of farm animals throughout the growing season. Depending on the seasons (from spring to winter, 100 kg of absolutely dry feed contains 83.5 -45.9 feed units.)

According to the Institute of Botany of the Academy of Sciences of Uzbekistan, Kochia prostrata occurs in the Kungey Alatau, Ketmentau, Dzhungar, Zailiy ridges, valleys of the Ili and Chu rivers, in the Chu-Ili mountains, Karatau, Kuramin, Ugam, Pskem, Chatkal, Turkestan, Zarafshan ranges. In addition, it is common in the Aral Sea region, the Gissar ridge, and the Pamir Mountain. In Uzbekistan recorded at an altitude of 1300-1500 m above sea level.

Seeds were collected from the natural population of (*Kochia prostrata* var. *virescens*) growing in the Malguzar Mountains of the Jizzakh region to create a gene pool and plant samples for analysis. It is envisaged to create technologies for obtaining and using biotechnologically active products for the reproduction of species of Kochia.

Results of Study of Development and Productivity of Secale Cereale in Desert Conditions

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Abstract

There are many artesian wells in the Kyzyl Kum Desert that can be used effectively and efficiently. In 2020, the features of cultivation, development and productivity of an unconventional rye plant (Secale cereale) in the region were studied.

Rye seeds were sown in experiments in October. Due to the lack of moisture in the soil per hectare, irrigation was carried out with the norm of 700 m^3 of water per hectare. Seeds germinated on day 6, full shoots were noted on day 15. The number of plants is 1220.0 + 42.2 thousand pieces / ha.

In order to study the viability of this culture in the Kyzyl Kum desert, it was noted that in winter, the number of plants decreased by 77.0 thousand pieces, and in spring - by 120.0 thousand pieces.

The growth of plants before cutting was 94.18 + 2.9 cm, and the number of shoots was 4.1 + 0.35 thousand pieces per hectare.

The yield of this crop was 27.4 + 1.6 t / ha of green or 5.5 + 0.42 t / ha of dry feed.

When irrigated in the KyzylKum desert, an unconventional plant species like rye (Secale cereale) can produce high yields of fodder mass and grain.

Predicting Fecundity of Perennial Graminoids Using Plant Traits in Northern Arizona Ponderosa Pine Forests

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Abstract

The overall goal of this project is to identify the functional traits and environmental conditions that drive variation in fitness (l) and vital rates (survival, growth, and reproduction) for native perennial graminoids in the *Pinus ponderosa*-bunchgrass ecosystem of the US Southwest. This study aims to quantify fecundity kernels for the 10 most abundant perennial graminoid species in northern Arizona. These kernels require information on probability of flowering, fecundity and establishment as a function of the continuous state variable, size. Fecundity (seeds per adult) is challenging to quantify in perennial graminoids because of the large quantity of seeds produced by each plant. To overcome this challenge, we developed a model to predict seed production using correlated plant traits that are easier to quantify than seed production itself. To build our model, we counted glumes as a proxy for number of seeds per plant. For each species we also collected plant trait metrics including basal area, flowering stalk height, basal leaf height, and number of flowering stalks to inform the seeds per plant prediction model. The resulting generalized logistic regression models show significant and positive relationships between the number of glumes produced by each species of graminoid and two plant trait metrics (number of flowering stalks and maximum flowering stalk height). These plant traits make excellent predictors of fecundity (McFadden pseudo $R^2 = 0.90$). The results of this study provide an efficient and accurate method to estimate fecundity in these graminoid species. Additionally, we modeled the probability of a species flowering as a function of plant size by using regression techniques, producing another element of the perennial grass fecundity kernel. These fecundity measurements will fill the gap in our long-term (19 year) demographic data set, and future work will use these data to build fecundity kernels in density-dependent population models.

Drought and Herbivory Impacts on *Artemisia tridentata* ssp. *Wyomingensis* in Eastern Wyoming Sagebrush Steppe

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Abstract

Extreme climate fluctuations, such as drought, are likely to increase throughout the 21st century, and may have strong impacts on the persistence of A. tridentata (sagebrush), a critical component of many ecosystems in the western US. Although sagebrush may be resistant to single year and moderate drought, it may be less resistant to prolonged severe drought. Additionally, disturbance events may exacerbate effects of drought on sagebrush due to trampling and consumption by grazers and browsers. In 2019, we established a fully factorial drought x grazing experiment in a sagebrush ecosystem within the Thunder Basin Ecoregion (Bill, Wyoming). In this experiment, light, moderate, and heavy grazing treatments were crossed with five levels of rainfall: ambient, -25%, -50%, -75%, and -99% and a browsing treatment of heavy (50%) or ambient. Within this experiment, we assessed performance and growth of sagebrush in these plots to address the following questions: 1) How do A. tridentata populations resist drought? 2) Are A. tridentata individuals more susceptible to drought when combined with grazing and or browsing? 3) Is the resistance of A. tridentata linked to the impacts after grazing the herbaceous community?

One hundred and five sagebrush individuals were measured within 54 plots (2x2 m each, n=3/treatment). Measurements included: crown volume, pre/midday water potential, soil moisture, leader growth of adult sagebrush, and grass community height. Results suggest sagebrush growth is strongly affected by prolonged drought. Trends in crown volume of heavily browsed sagebrush revealed they are more susceptible when combined with drought. These findings suggest that different types of stress may interact to magnify impacts on plant communities, which may have implications for ecosystem services, such as wildlife habitat. As such, we advise that understanding the impacts of multiple simultaneous drivers will be critical for informing land management decisions under future climatic scenarios.

Effects of temporal variability on plant community response to interactions between prescribed fire, soil disturbance and water addition.

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Abstract

Climate change is expected to interfere in the frequency, intensity, and extent of disturbances. Improved knowledge of disturbance interactions is fundamental to adequately predict plant community response and foster management practices for resilience. Based on that, we aimed to experimentally assess the short-term plant community response to multiple disturbances, weather and other time-dependent conditions. We set up a randomized complete block design experiment in 2016 and repeated the same experiment in 2017, both in a Nebraska Sandhills mixed-grass prairie. Each experiment featured a 5-block design with a 3x2x2 factorial arrangement of soil disking, water addition, and fire treatments, and we monitored them over two years. With this design, we measured plant community response to disturbance and monthly rainfall change. We used mixed-effect models and ordination analysis to analyze the data. Consistent patterns between experiments were: (i) fire had the most prominent impact on plant community composition and biomass compared to other disturbance events, (ii) positive effect of fire on bare ground cover, (iii) negative effect of fire on plant annual cover in the first year followed by a positive effect in the following year, and (iv) forb frequency was significantly affected by fire and responsive to change in weather. Warm- and cool-season grasses cover and biomass, as well as forb germination were most affected by the temporal replication of the experiment. Differences in plant community response between experiments are likely due to a sudden and intense drought event (i.e. flash drought) in the middle of the growing season in 2017. Overall, the studied plant community was resistant to multiple disturbance interactions, and we did not see evidence of large or non-linear changes in the community structure over the short term.

Increasing Rocky Mountain Juniper on southwestern Montana Landscapes: Encroachment or State Change?

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Abstract

Conifer presence in southwestern Montana landscape photos contrasts sharply with photos from the late 19th and early 20th centuries. Not surprisingly, managers are inquiring about the apparent increase in juniper on School Trust lands before beginning control mitigation. Specifically, is the apparent increase due to ecological succession or encroachment? Range inventories indicated the Table Mountain area supports Rocky Mountain Juniper/Limber Pine and Big Sagebrush/Idaho Fescue community types. To determine ecological status we collected herbaceous cover, tree density, aged trees, and described soils on 12 randomly selected sites. Data summary yielded three stand types: Type I, II, and III based on observational abundance of juniper along a gradient from low abundance to high abundance of stems. Type 1 had a stem density of 496 stems/ha (201 stems/ac), Type 2 had 720 stems/ha (292 stems/ac), and Type 3 had 780 stems/ha (316 stems/ac). Rocky Mountain juniper (*Juniperus scopulorum*) in Type 1 ranged from 0-40 years old, in Type 2, 6-55 years old, and Type 3, 6-75 years old. Limber pine (*Pinus flexilis*) in Type 1 ranged from 21-30 years old, Type 2, 6-35 years old, and Type 3, 11-40 years old. Type 1 supported 3,200 kg/ha (2,854 lbs/ac) yielding 3.2 AUMs/ha (1.3 AUMs/ac). Type 2 supported 900kg/ha (803 lbs/ac) yielding 0.9 AUMs/ha (0.4 AUMs/ac). Type 3 supported 600kg/ha (535 lbs/ac) yielding 0.6 AUMs/ha (0.2 AUMs/ac). All sites had well developed mollic soil horizons. Dominant understory species included Idaho fescue (*Festuca idahoensis*), bluebunch wheatgrass (*Pseudoroegneria spicata*), and mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*). Decreased diversity of understory species, tree age class, and soil characteristics were used to determine that this site is experiencing Rocky Mountain juniper encroachment into an A*rtemisia tridentata/Festuca idahoensis* habitat.

Rangeland Seed Bank Dynamics: An Interpretive Model for Understanding How Soil Properties Influence Soil Seed Bank Suitability

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Abstract

Soil seed banks – living seeds in the soil profile and on the soil surface – are an integral component of rangeland ecosystem dynamics. The soil seed bank represents a source of regenerative potential and can influence rangeland plant community dynamics, as well as management and ecological restoration implications. While their importance is recognized, rangeland soil seed bank dynamics are difficult to predict due to the number of interacting abiotic and biotic factors. Soil properties may have unique characteristics determining the suitability of a soil to store viable seeds. Unlocking what drives these conditions allows us to begin to build a predictive framework for understanding seed bank dynamics. We are working on the development and verification of an NRCS soil seed bank suitability interpretation tool in New Mexico, U.S.A. rangelands. Using soil physical, chemical, and climate data available from the National Soil Information System (NASIS), this tool will provide a mechanism to predict which soils have the greatest potential of storing and maintaining viable seeds. The model development and verification portion of the project will control for and increase our understanding of key soil properties that influence seed viability and longevity in rangeland soils. The final interpretation tool will be able to be used to prioritize areas for management treatments such as active seeding. Seeding in soils with a greater suitability to maintain viable seeds over time can increase the likelihood that those viable seeds will be present when favorable germination and establishment conditions are met in highly variable environments.

Biomass Production and Temporal Stability Are Similar in Switchgrass Monoculture and Diverse Grassland

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Abstract

Research into herbaceous bioenergy production has focused on identifying grassland systems that are both productive and temporally stable, where stability equals the ratio of mean biomass production to its temporal standard deviation. The question remains as to effects of community properties, including species richness, on temporal stability. We compared aboveground net primary productivity (ANPP) and the temporal stability in ANPP of unfertilized grassland planted either as a mixture of native perennial grass and forb species or monoculture of *Panicum virgatum* L. (switchgrass) in Texas, USA. ANPP varied in response to inter-annual variation (IAV) in precipitation. The precipitation effect on ANPP stability was mediated through two components of the influence of a single community property, community (species-abundance) weighted values of leaf dry matter content (LDMC), on productivity. These components include community LDMC and ANPP-LDMC regressions. Stability was similar between vegetation types but was regulated by different components of the LDMC effect on ANPP in mixture and switchgrass. Temporal stability in mixture depended mainly on ANPP variation that resulted from change in community LDMC. Stability of switchgrass depended primarily on ANPP variation that resulted from precipitation-caused change in ANPP-LDMC regressions. Stability declined as ANPP increased in mixture because LDMC variation increased when productivity was high. We find that ANPP and ANPP stability can be as great in an unfertilized planting of a switchgrass monoculture as diverse mixture of grassland species. Similar levels of stability can be achieved via different components of the LDMC effect on productivity.

Looking at Rangelands in the Great Basin and Intermountain West Through Different Lenses: Revisiting Ideas Presented by Mack and Thompson (1982)

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Abstract

One of the ever-present goals of science is to identify generalizable "truths" that guide our understanding of the world we live in. For rangeland ecologists and managers, there is a definite tradeoff between the benefits of being able to make broad generalizations and the very real danger of inappropriately oversimplifying extremely complex ecosystems and ecological processes. Therefore, it is important to periodically identify and reevaluate influential claims to determine if they are appropriate, help us understand the world we live in and support effective management. We suggest that one of the most influential ecological claims of the past 40 years is based on ideas presented by Mack and Thompson (1982; American Naturalist, 119:757-773); that Great Basin and Intermountain West plant communities evolved with few or perhaps no large hooved-grazing animals. We question Mack and Thompson's position and investigate the possibility that it represents an oversimplification of complex, heterogeneous, and diverse rangeland ecosystems. We revisit some of Mack and Thompson's (1982) interpretations of rangeland plants and plant communities, forage quality and nutrition, and soil biotic crusts east and west of the Rocky Mountains adding the information necessary for a more comprehensive interpretation. We finish by proposing that this reinterpretation is very compatible with a management paradigm that focuses on outcomes and ecological processes.

Variable Topsoil Depths: Returning Heterogeneity to Reclaimed Grasslands

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Abstract

Ecosystems are fundamentally complex due in part to topoedaphic features where variability provides heterogenous plant structure and composition across the landscape. Heterogeneous vegetation is a defining characteristic of native grassland ecosystems but is continuously threatened by changes in land-use and the invasion of exotic species. Post-mining reclaimed grasslands lack topoedaphic variability, and over time invasive species cover increases. This culminates to create a homogenous landscape. The objective of this project is to determine how variable topsoil depths and different seeding methods effect the vegetation community composition, exotic grass invasion, and biomass production. Research was conducted at two different locations (Coteau and BNI) where four distinctive topsoil depths were respread during reclamation; depths differed between locations but ranged between 8 and 30 cm. During the first season, half of the treatments were planted to a cover-crop or a native seed mix. By season two, both plots were planted to the same native seed mix. We found no interaction or differences ($P>0.05$) between topsoil depths and seeding methods when assessing plant species richness, biomass, or the vegetation community at Coteau. At the BNI location, there was no interaction ($P>0.05$) between topsoil depths and seeding methods; however, there was a difference ($P>0.05$) between individual topsoil depths and seeding methods when assessing plant species richness, biomass, and vegetation community. These findings will supply mining companies new reclamation practices that will meet standards for performance bond release and improve reclaimed grassland plant heterogeneity.

Evaluation of Morphological Traits of 14 Alfalfa Populations for Persistence in Rangelands

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Abstract

Alfalfa is a fundamental component of feed for dairy and beef cattle and a focal forage legume species worldwide due to its high nutritional value, forage production and symbiotic nitrogen fixation ability. However, environmental stressors limit alfalfa stand establishment and persistence in the arid and semi-arid regions. Development of alfalfa cultivars enable to adapt to abiotic and biotic stress conditions are greatly needed. The objective of this study was to evaluate and identify desirable morphological traits as potential parent materials for breeding improved persistence new cultivars in rangelands. Thirteen yellow-flowered alfalfa (*Medicago sativa* subsp. *falcate*) populations from the National Plant Germplasm System and one commercial cultivar (Final Answer) (*Medicago sativa*) as control were evaluated. One hundred uniform seeds were selected from each entry. Seeds were scarified and inoculated with *rhizobium* before planting in plastic cone-containers in a greenhouse. After 114 days of planting, ten plants from each population were randomly selected and excavated to examine morphological traits: crown diameter and number of crown buds; stem and root length; number of crown shoots; biomass for leaf, stem, root, and root to shoot ratio. We identified PI 634114 had the highest root to shoot ratio (1.9) followed by PI 631678 (1.2), while PI 5022441 had the highest crown buds density (0.8 buds/mm^2) followed by PI 631678 (0.7 buds/mm^2). Although PI 467980 and Final Answer had the highest shoot and root biomass, number of crown shoots and crown diameter, but low root to shoot ratio and the lowest crown buds density (0.2 and 0.26, respectively). High root to shoot ratio and high crown buds density are desirable phenotypic traits for enhancing vegetative reproduction potential and persistence in harsh environments. High aboveground growth with low root to shoot ratio indicates good stand establishment but might reflect poor persistence under unpredictable environments.

Remote Sensing & UAV Application

Geospatial Analysis of the Pattern, Dynamics and Human/climate-Induced Drivers of Savanna Transition and Savannization in Old Oyo National Park, Nigeria

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Abstract

In recent times, an unprecedented rate of savanna transition occurs in tropical protected landscapes from anthropogenic and climate-induced factors. Its understanding over a period provides insights into the success of any ecological intervention. This study aimed to determine the pattern, dynamics, intensity and eco-climatic drivers of savanna conversion and restoration within the last four decades in Old Oyo National Park (OONP), Nigeria. The data collection and analysis used field observations, geospatial technology, and boosted regression tree algorithm. Three-time series (1986, 2003 and 2019) of Landsat satellite imageries downloaded and subjected to supervised image classification. The results revealed that the mixed open savanna areas covered the highest landmass of OONP. It covered 1399.69 km^2 (55.73%) in 1986, reduced to 1254.99 km^2 (49.97%) in 2003, and decreased again to 1034.40 km^2 (41.19%) in 2019. Twenty-two of forty-three eco-climatic variables is the most significant drivers to savanna transition and savannization between the year 1986 and 2019. Partial dependence plots showed a strong relationship of bush burn severity, distance to host communities, distance to rivers, distance to roads, elevation and slope on the probability of the savanna transition and savannization. Other significant variables include average monthly rainfall (April, July - October), average monthly temperature (January) for savanna transition, and average monthly rainfall (March, July - November) for savannization. Despite savanna transition to forests and outcrop vegetation, prescribed burning, well-organized conservation awareness programmes in host communities, forest restoration initiatives in locations with elevation above 300 meters recommended mitigating the climate change effects and reduce the rate of savannization.

Comparison of Willow (Salix spp.) Metrics Collected with Ground-Based Sampling Methods and a Small Unmanned Aerial Vehicle

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Abstract

Willows (Salix spp.) are riparian shrubs that commonly occur along streams in rangeland watersheds. They serve as habitat for many species of small animals, stabilize stream banks, and play a key role in maintaining proper functioning condition in riparian systems. Beavers use willow branches for building dams, and the ponds created serve as vital habitat for many species of fish and aquatic insects, freshwater crustaceans, amphibians, and plants. Quantitatively characterizing dense communities of riparian vegetation often requires time- and labor-intensive, error-sensitive ground-based sampling methods. High-resolution data from small Unmanned Aerial Vehicles (sUAV) are becoming more available and affordable to land managers, but more research is needed to assess the strengths and limitations for rangeland riparian vegetation applications. This study compares dimensional metrics of willow communities derived from ground-based sampling methods with metrics derived from high-resolution imagery obtained with an sUAV to estimate riparian willow dimensions, abundance, and distribution in a small mixed-use rangeland watershed in southeastern Wyoming. Ground-based sampling surveys were conducted over the 2019 and 2020 field seasons and included line-point intercept transects, modified belt transects, allometric volume estimations, and differential Global Navigation Satellite System (GNSS) surveys. High-resolution RGB imagery was collected with an sUAV over several flights throughout 2020 and was used to create a digital surface model and estimate shrub dimensions. Relative to the application scope and scale, it is possible to formulate a combination of methodologies to provide efficient and confident estimations of riparian willow dimensions, structure, abundance, and distribution. High-resolution remote sensing methods, such as sUAV, coupled with ground-truthing can offer advantages over single application ground-based sampling for quantifying riparian vegetation metrics.

An Operational Approach to Forage Mass Estimation Using Drones

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Abstract

The use of Unmanned Aerial Vehicles (hereafter: “drones”) has exponentially increased in recent years for monitoring and managing rangelands. High-resolution cameras and improved sensors provide an opportunity to investigate pasture-scale sampling methodology as an operational approach to estimate forage mass on rangelands using 3D models derived from drones. Our objectives were to 1) develop a protocol for sampling forage standing crop at the pasture-scale and (2) to compare field-based and drone-based forage estimation methods. To accomplish this, we used a DJI phantom IV pro RTK to acquire imagery which was processed to create orthoimagery, digital terrain models, and digital surface models. We conducted 2 flights at altitudes of 50 and 100 meters above ground level within the South Texas Plains ecoregion. We performed three biomass sampling techniques: double sampling with the UAV, traditional double sampling method, and a traditional quadrat clipping method. Linear regression analysis was used to evaluate relationships between UAV derived vegetation volume for each flight altitude and the forage biomass derived from each biomass sampling method. The results of this research will provide guidance on the operational approaches to use drones for forage estimation. This type of information can be used for the collection of a large number of samples using a non-destructive method to estimate forage standing crop for grazing animals. We expect that this approach will allow for efficient large-scale rangeland analysis to assist with stocking rate and rangeland monitoring.

Using Targeted Training Data to Develop Site Potential for the Upper Colorado River Basin

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Abstract

Site potential refers to an area's long-term vegetation growth potential in a relatively undisturbed state, which can provide a baseline of vegetation productivity. Modeling and mapping site potential helps spatially identify naturally occurring variations in vegetation as opposed to variations caused by land management activities or disturbances. We integrated satellite data (250-m enhanced Moderate Resolution Imaging Spectroradiometer (eMODIS) Normalized Difference Vegetation Index (NDVI)) with land cover, soils, elevation, slope and aspect, and climate data into regression-tree software to create a snapshot of spatially explicit predictions of shrub and grass site potential in the Upper Colorado River Basin (UCRB). While we incorporated NLCD and Monitoring Trends in Burn Severity (MTBS) datasets into our training filter, the most accurate site potential models (Shrub independent validation R^2 = 0.89, MAE = 4.34; Grass independent validation R^2 = 0.94, MAE = 4.13.) included newly released USGS products – Land Cover Monitoring Assessment & Projection datasets: Change Magnitude and Spectral Model Quality. Change Magnitude indicates when an unpredicted deviation in the spectral signal occurs and what is the deviation's intensity. The timing should be coincident with the occurrence of a disturbance or land management activity. Spectral Model Quality provides the type of time series model applied in the current year; i.e., no model, a partial model, or a full model. Training data pixels met four criteria: 1) the 2001, 2006, 2011, and 2016 NLCD iterations all classified a pixel as shrub (for shrub model) or grassland/herbaceous (for grass model), 2) MTBS recorded no fires during the period of 1984 – 2017, 3) the Change Magnitude dataset indicated there were no unpredicted deviations from 1985 – 2017, and 4) all Model Quality data were developed by a full model, indicating high model quality. Developing quality training data using appropriate land cover and disturbance datasets helps build stronger site potential models.

Developing Spectral Signatures for South Texas Grasses Using UAV Mounted Multispectral Sensors

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Abstract

Compared to traditional vegetation monitoring and identification methods, unmanned aerial vehicles (UAVs) are less expensive, and allow the least amount of disturbance to the landscape. Multispectral sensors have become part of the drone toolbox for vegetation monitoring. Multispectral sensors can capture five spectral bands (blue, green, red, red edge, near infrared) which can be used to develop spectral signatures for remote sensing classification approaches. Drone mounted multispectral sensors allow for high spatial resolution (<2.54-cm resolution). This information can potentially be used to classify and quantify the amount and spatial distribution of species over large areas in rangelands. Our goal is to develop spectral signatures for 16 native South Texas grasses. To achieve this goal, we are acquiring data from monoculture plots at the South Texas Natives Project Farm and the USDA NRCS E. "Kika" de la Garza Plant Materials Center. We will be conducting monthly flights for two years using a DJI Phantom IV Pro UAV mounted with a MicaSense RedEdge MX multispectral camera to capture spectral information at different temporal scales for the 16-target species. If each species has a unique and identifiable spectral signature, we will then acquire data from pastures containing these species and will assess the feasibility of quantifying species composition using drone mounted multispectral sensors. Once this first phase is completed, we plan to use the spectral signatures and Sentinel-2 satellites to estimate species fractional cover in rangelands. This project will bring an opportunity to assess landscape species composition using remote sensing approaches and potentially evaluate ecosystem function and structure over large areas.

Predicting Diet Quality and Cattle Weight Gains from Satellite Time Series

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Abstract

Adaptive rangeland management seeks to mitigate the effects of fluctuating forage conditions on cattle performance, while also meeting rangeland health and conservation objectives. Achieving this requires an understanding of how changes in forage production and quality influence indicators of performance, such as cattle weight gains. Infrequent concurrent ground observations of cattle performance and forage conditions, especially forage quality, have limited this understanding in the past. We combined multi-temporal field observations of diet quality (weekly) and weight gain (monthly) with satellite-derived estimates of forage production and diet quality (pseudo-daily) to model daily weight gains of free-ranging yearling cattle in the shortgrass steppe. We used an existing satellite-derived estimate of forage production and developed a new estimate of diet quality based on satellite-derived phenological metrics. We were able to accurately predict diet quality from satellite imagery and found that phenological metrics related to the timing and rate of green-up and senescence were most important for predicting diet quality. Our model predicting monthly weight gain from satellite-derived forage production and quality estimates performed reasonably well (R^2 = 0.69) and showed that diet quality was a strong predictor of weight gain across a wide range of forage production, demonstrating that cattle performance was strongly affected by forage quality, even if adequate forage was available. Season-long analysis across 40 different pastures grazed over a 10-year period showed that forage quality declined rapidly after spring green-up without adequate late-summer precipitation, and modeled average daily gains were lowest in years when spring green-up occurred early, before the grazing season. The satellite-based approach presented here offers new opportunities for adaptive rangeland management, such as identifying within-season triggers to rotate livestock, predicting livestock performance and when supplemental protein may be needed, or timing the grazing season to better match earlier spring green-up caused by climate change and species invasion.

Tracking the Above- and Belowground Phenology and Physiological Response of Sorghum Bicolor to High-Sodic Conditions Using Optical and Radar Ranging Technologies in Fallon, NV

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Abstract

Saline and sodic soils are major abiotic stressors on the production of flood irrigated crops in drylands. Additionally, carbon stock estimates in drylands are uncertain, particularly because belowground estimates are at times uncoupled from above ground estimates. We conducted a crop phenotyping remote sensing study on five genotypes of sorghum [*Sorghum bicolor* (L.) Moench], a drought and salt tolerant crop, to assist in the molecular breeding of salt-tolerant cultivars. A control and a spatially heterogeneous saline plots were established in collaboration with the Nevada Agricultural Experiment Station (NAES) and the USDA Plant Materials Center (USDA-PMC) in Fallon, Nevada. This location is representative of the variable salinity conditions typical of Northern Nevada's soils as well as a model site for belowground biomass dynamics in drylands. We generated pre- and post-harvest salinity and other soil attribute maps of the two plots using spatial interpolation. We hypothesized that above- and belowground 3-D structural phenology of the five genotypes would be differentially affected across the flood irrigated salinity gradient. Phenology of coarse-root depth and 3-D structure from pre-planting to harvest was non-invasively measured 15 times using a real-time kinematic (RTK) GPS-mounted IDS GeoRadar dual channel (400 to 900 MHz) ground penetrating radar (GPR) system. Plant height and 3-D structural phenology of the 5 varieties was mapped using a FARO Focus 330X 3-D terrestrial laser scanner (TLS). Flood irrigated driven soil moisture was measured using the internet of things time-domain reflectometry (IoT-TDR). We found differences in above- and belowground 3-D structural phenology across the five genotypes in response to the salinity gradient.

Using Lidar to Estimate Herbaceous Understory Biomass in Southwestern Conifer Forests

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Abstract

Anthropogenic impacts have drastically increased the density of southwestern conifer forests resulting in less herbaceous understory biomass and altered functional group composition. Restoration treatments (i.e., forest thinning, prescribed burning) reduce tree density and alter overstory structure increasing herbaceous understory biomass and shifting functional group composition towards remnant populations. Relationships between overstory structure and understory production provide an opportunity to implement monitoring of understory plant communities over broad areas through remote sensing. Light detection and ranging (lidar) has proven to be an accurate method for quantifying overstory structure and provides the opportunity to estimate herbaceous understory functional group (i.e., C_3 graminoid, C_4 graminoid, forb) biomass and composition. In this study, we aimed to 1) use lidar derived overstory structure to predict herbaceous understory biomass across plant functional groups, and 2) investigate the influence of important overstory structural variables with total biomass predictions. We sampled herbaceous understory biomass in thirty (1-m^2) plots stratified by overstory canopy cover (%) and arrangement. Lidar variables (n = 342) were calculated for a circular plot (0.04 ha) centered on each understory quadrat. We used Boruta feature selection to identify the important predictors for C_3 graminoid, C_4 graminoid, forb, and total herbaceous biomass followed by a stratified k-fold cross validation of random forest models. We found that the median absolute deviation (MAD) was lowest for C_4 graminoids (1.71 g) and highest for total herbaceous biomass (20.6 g). Variables using volumetric pixels (i.e., summarizing lidar plot data into multiple 3-dimensional cubes), lidar-derived crown area, and the percentage of like adjacencies resulted in the highest importance values for total herbaceous understory biomass. Using these lidar-based measures of overstory structure, we can capture herbaceous understory biomass of functional groups within a reasonable margin of error.

Pasture Biomass Estimation using UAV Lowest Point Analysis

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Abstract

The use of Unmanned Aerial Vehicles (UAV) has exponentially increased in recent years for monitoring and managing rangelands. High-resolution cameras and improved sensors provide an opportunity to investigate pasture-scale sampling methodologies as an operational approach to estimate forage mass on rangelands using 3D models derived from drones. Our objectives were to 1) assess the feasibility of a protocol for sampling forage standing crop at the pasture-scale and (2) evaluate the efficiency of using two altitudes on forage mass estimation. Our study was conducted in an 830-ha pasture. We selected seven sampling sites (12-ha each) where we collected field data using the traditional quadrat clipping method. For each sampling site, we collected biomass from 10 quadrats. For each quadrat, we dried and obtained the dry mass weight. We acquired aerial imagery using a DJI phantom IV pro RTK with two flight altitudes at 50m and 100m above ground level. The imagery was processed to create orthoimages at a resolution of 1.5cm and 3cm respectively and digital surface models using the lowest point analysis. Simple regression analysis was used to compare data derived from the UAV and field data for each altitude. The results of this research will provide guidance on the operational approaches to use drones for forage estimation. This type of information can be used as a non-destructive method to estimate forage standing crop for grazing animals to aid in efficient large-scale rangeland analysis for assessing stocking rate and conducting rangeland monitoring.

A Pilot Study to Estimate Crude Protein in Tanglehead Using Unmanned Aerial Vehicles in Semi-Arid Rangelands

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Abstract

In recent years, advancements in the use of unmanned arial vehicles (UAV) in research has provided new avenues to collect data. In this study we are testing the application of UAVs to estimate forage nutrient content information for tanglehead (*Heteropogon contortus* (L.) P. Beauv. ex Roem. & Schult.Show) in south Texas rangelands. The objective of this study is to determine the relationship between high resolution UAV imagery and crude protein content in tanglehead determined by traditional forage analysis. For two consecutive weeks on a cooperating private ranch in Jim Hogg County, Texas, five different 10-20 m^2 patches of tanglehead were mowed each week with a gas-powered grass trimmer to create variation in plant growth stage, crude protein content and spectral signatures. After five weeks of regrowth had occurred, ten plants of each growth stage (vegetative, elongated, reproductive, mature, and decaying) were marked with a 0.25 m^2 spray-painted quadrat. We conducted one flight using a DJI Phantom IV Pro on a 3-ha tanglehead monoculture plot. Using a multispectral camera (Micasense RedEdge MX), spectral signatures were recorded at a flight altitude of 50 m above ground level. After the flight, marked plants were clipped and put in individually identified bags. The samples were dried, ground and sent to the Texas A&M AgriLife Extension Service Soil, Water and Forage Testing Laboratory for wet chemistry and near infrared spectroscopy analysis. Imagery was processed in Pix4D and reflectance value orthomosaics were generated for each band. We obtained spectral signatures and vegetation indices for each sample. Regression models were developed to use spectral signatures and vegetation indices to predict the tanglehead crude protein content.

Identifying Spectral Signatures for Bunch Grasses Using UAV Mounted Multispectral Sensors

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Abstract

With the use of UAVs (unmanned aerial vehicles), we can safely collect aerial imagery with high spatial and temporal resolution compared to other methods of aerial imagery collection. Multispectral cameras can be mounted on UAVs and are capable of capturing high spatial resolution (<2.54cm) images with multiple spectral bands (blue, green, red, red edge, and near-infrared). These bands can be analyzed individually to identify unique spectral signatures for rangeland vegetation. The goal for this project is to develop spectral signatures of four bunch grass species, Silver bluestem (*Bothriochloa saccharoides*), Switchgrass (*Panicum virgatum*), Knotroot bristlegrass (*Setaria geniculata*), and Halls panicum (*Panicum hallii*), using multispectral imagery collected over six months of routine flights. We are collecting imagery using a DJI Phantom IV Pro UAV mounted with a MicaSense Red Edge MX multispectral camera. We are conducting flights at an altitude of 50m above ground level. We are acquiring imagery from monoculture plots located at the *South Texas Natives* Project Farm in Kingsville, Texas. The collected imagery will be processed in Pix4D and reflectance maps for each band and an orthomosaic of the raw imagery will be created. In ArcMap we are creating boundaries around each species, buffers to get rid of edge effect and then placing 200 random points for each species. Then we will extract the values for each random point. With those reflectance values, we will make box graphs and also take the mean value for each band and create a graph to depict the spectral signature. This research will provide a digital library that will allow further image classification of these species at different times of the year. This will help efforts in mapping vegetation communities in rangelands across South Texas.

Before-and-After Change Detection of the Effect of Dormant Season Grazing by Sheep on the 3-D Structure and Biomass of an Annual Invasive's Fuel Bed Characteristics

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Abstract

Invasion of over 80% of western U.S sagebrush rangelands by annual invasive grass cheatgrass (*Bromus tectorum* L.) have led to an increase in wildfires and a contemporaneous conversion of the physiognomic vegetation structure of fire-intolerant sagebrush/desert shrublands to annual grasses. Understanding how to stop or slow down the wildfire-driven type conversions from sagebrush/perennial bunchgrass vegetation types to cheatgrass monocultures is essential to stabilizing the forage base for livestock and sagebrush obligates such as the Greater sage grouse (*Centrocercus urophasianus*). We are conducting a before- and-after livestock dormant season grazing impact and control (BACI) remote sensing-based study on 4 of USFS Region 4's cheatgrass-invaded landscapes for 4 years in the northern Nevada portion of the Great Basin. We have established a study in northern Nevada. We are using a tiered remote sensing approach whereby traditional field inventory methods, terrestrial laser scans and multispectral UAV collections are made in 6 X 1600m^2 sample plots per landscape. Within these plots, 3-D fuel bed characteristics including a flora, depth, biomass, and vegetation and litter height and composition are collected and imputed to the landscape-scale using machine learning tools in concert with Landsat 8 and Sentinel satellite data before- and after livestock grazing. Image differencing of the 3-D imputed maps This study will determine the effect of livestock grazing on the 3-D structure and biomass of rangelands, but we hypothesize that the efficacy of this experiment, i.e., reduction in annual grass fuel loads and compositional dominance of perennials, will not be detected for at least 3-years. Consequently, we present here methods and preliminary results from the first year of research.

Convolutional Neural Network Land Cover Classification for Wildlife Habitat Is South Texas

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Abstract

Recent advances in remote sensing have paved the way to improve classification approaches for land cover through artificial intelligence algorithms. New approaches include deep learning, machine learning, and artificial intelligence. Deep learning is a subset of machine learning, which uses artificial intelligence to predict land cover types. Deep Learning is a methodology that relies on multiple layers of nonlinear processing for feature identification and patterns. By using deep learning approaches, we can potentially improve classification processing time and develop a higher land cover classification accuracy. The goal of our research is to develop deep learning workflows that can be used to classify NAIP imagery, sentinel imagery, UAV imagery in South Texas. Our specific objectives are to 1) create classification models for South Texas and 2) Evaluate the accuracy of our image classification algorithm. We are using ArcPro for creating training sets (image chips) these training sets are then imported into ERDAS Imagine to incorporate them into a spatial model. This spatial model will use a random forest to delineate training samples to a class and create an output classified image. By achieving these goals, we hope to be able to perform faster image processing and highly accurate classified imagery for study areas in South Texas rangelands. This will provide an important baseline for range and wildlife habitat studies and improve models such as habitat suitability models, habitat use and preference models as well as land cover change analysis.

Restoration Tools & Approaches

Effectiveness of Aerial and Plug Seeding of Big Sagebrush (Artemisia tridentata) after the Henry's Creek Fire

Amber Johnson[1], Joseph Galanti[1], Jessica Call[1], Jericho Whiting[1], Ryan Walker[2], Logan Peterson[2]

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Abstract

Wildfire is a common occurrence in the Great Basin, burning nearly 20,000 km^2 every year. Many species depend on sagebrush (*Artemisia* spp.) habitat, making reestablishment of sagebrush important. Seeding after wildfires is a common practice to restore sagebrush. In 2016, the Henry's Creek Fire burned two-thirds of the Tex Creek Wildlife Management Area (hereafter Tex Creek), which covers 143 km^2 in southeast Idaho. In 2017, the Idaho Department of Fish and Game (IDFG) began restoring sagebrush in Tex Creek using aerial seeding and plug planting. We compared the effectiveness of aerial seeding, plug planting, and natural recovery of big sagebrush (*A. tridentata*) in two regions in Tex Creek; one of high elevation and one of low elevation. We predicted aerial and plug overlap areas would have the highest sagebrush height and density, and untreated areas would have the lowest sagebrush height and density. We also predicted the region of higher elevation would have higher sagebrush height and density than the lower region. From September to November 2019, we randomly selected 111 points to quantify sagebrush density and height using 50 m transects. We also estimated ungulate use by counting fecal piles within transects. Contrary to our predictions, sagebrush height and density did not vary by treatment in the upper region, and no difference in shrub height existed between the two regions. In the lower region, however, mean density was higher in the treated groups than the untreated group ($p < 0.0001$). Twice as many elk (*Cervis elaphus*) fecal piles occurred in the lower region as the upper region ($p = 0.0017$). Our results may be confounded by unmeasured factors such as aspect, precipitation, slope, and soil type; however, our results can help IDFG understand how to effectively use these methods to restore sagebrush in southeastern Idaho.

Response of Sagebrush Steppe Plant Species to Commercial and Early Seral Mycorrhizal Inoculation

David Prado-Tarango, Ricardo Mata-Gonzalez, Matthew Hovland

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Abstract

Arbuscular mycorrhizal fungi (AMF) are important components of ecosystems. AMF colonize roots of most vascular plants increasing the plant ability to obtain nutrients, moisture among other benefits. However, such responses are poorly understood in rangeland plants and studies have provided contrasting results, indicating that more research on mycorrhizal inoculation is required. We wanted to understand how three native and one introduced plant species would respond to mycorrhizal inoculation from two sources: commercial mycorrhizal inoculum and the mycorrhizal community present in a disturbed (early seral) field soil. Those sources were selected because they are the most likely to occur during a restoration program. Evaluated plant species were *Artemisia tridentata* ssp. *wyomingensis*, *A. arbuscula*, *A. nova* and *Taeniatherum caput-medusae*. We collected the early seral field soil in a typical sagebrush steppe ecosystem. The plants were grown in greenhouse conditions on containers of 656 ml, 6.35 cm diameter and 25.4 cm depth. Our treatments were autoclaved early seral field soil, inoculated autoclaved early seral field soil, early seral field soil and inoculated early seral field soil. All plants were collected after six and 15 weeks of growth and we measured their biomass production and mycorrhizal colonization. We found that the commercial inoculum did not colonize our plant species as we found colonization only in the treatments involving early seral field soil. Preliminary tests indicated that the commercial inoculum was viable, but factors preventing colonization in our target species remain unknown. Colonized plants in field soil had a growth depression compared to non-mycorrhizal controls, which could be associated to carbon transfer from plant to fungi or a pathogenic response. More research is required to proper understand the plant responses associated to mycorrhizal colonization especially on field conditions that could benefit restoration programs in the sagebrush steppe.

Forb Common Garden Research to Inform Seed Transfer Guidance for Restoration

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Abstract

As landscape-scale disturbances increase across public lands, understanding how to restore plant communities is of critical importance. Part of incorporating native plants into restoration is understanding the level of flexibility they display when moved away from their location of origin. Some species may be more flexible to novel conditions than others, and many arid-land species display population-level variation in their performance. Common gardens are a tool for examining variation in performance across the range of a species, and the best way to develop seed transfer guidance for restoration. While past common garden work conducted by the Great Basin Native Plant Project (USFS – Rocky Mountain Research Station and BLM – Plant Conservation and Restoration Program) has focused on dominant perennial grasses, their current work focuses on native forbs. We selected three species of forbs common across the Great Basin and known to be of interest for restoration due to their value as forage and cover resources for wildlife. To allow for population genetics work to occur alongside the common garden study, both seeds and plant tissue were collected for some species. In this talk, I will discuss the technical aspects of carrying out a large-scale common garden project and present preliminary results for the first year of plant performance. A project of this scale also requires many partners to coordinate resource acquisition, land use, and garden monitoring. The end product will be a spatially-explicit restoration tool for land managers that will inform the appropriate selection of seed for particular restoration projects, as well as multiple research publications. This work is a step toward the larger goal of creating a streamlined approach to seed transfer development for forbs, with the plan of monitoring plant performance for three species in the 2021 field season and adding two more species in fall 2021.

Seed Traits Impact Ant-Seed Predation Rates on Rangelands in the US Southwest

Trace Martyn, Elise Gornish

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Abstract

Many rangeland plant restoration projects seed species into an area to enhance plant establishment. Many studies, however, have had varying levels of success in plant establishment via seed. One known but uncommonly explored hinderance to successful seed restoration is ant-seed predation. Ants can move over 30 grams of seed per hour and can store up to 300,000 seeds in each nest annually. This could result in a large loss of seed (and money) for restoration projects on rangelands.

After observing loss of seed from a recently seeded restoration project, we designed an experiment comparing seed predation rates to seed traits such as seed mass and the presence of seed structures (e.g. awns) across 20 different seed species. We performed a 'cafeteria' study for preference for three different ant mounds across four trial periods of 24hrs (each mound having a different ant diversity based on pitfall traps). We found that seed with larger volume had reduced predation across all mounds when first presented. However, mounds with larger ant species increased predation of large-volume seeds over time compared to mounds with majority small ant species. Additionally, we found that seeds with structures (such as awns or a seed coating) reduced predation over time than those seeds without any structure. Our results demonstrate that, if possible, seeding with larger species can reduce initial ant predation. However, for smaller seeded plant species or if seeds are to persist for long periods of time on the landscape, keeping or adding seed coatings/structures could potentially reduce predation. These results could help improve species establishment in rangeland restoration seeding, especially in areas with known high ant activity, such as the US southwest.

Perennial Grass Establishment Following Fall and Spring Imazapic Applications

Charlie Clements, Dan Harmon

USDA-ARS, Reno, USA

Abstract

It is critically important that land managers have useful information available to them when attempting proper weed control practices in efforts to improve restoration/rehabilitation efforts on cheatgrass-infested rangelands. We were approached on the topic of applying the well known pre-emergent herbicide, *Imazapic*, in the spring of the year on cheatgrass-infested rangelands and then seeding that treated habitat the following fall. Our experience has been that *Imazapic* has a soil activity of 12-15 months and the residual activity could damage seeded species seedlings and decrease overall establishment of seeded species. We initiated an experiment by which we applied *Imazapic* in the fall of 2017 and the spring of 2018 @ 70g ai/ha (6oz/ac). The treated plots were seeded in the fall of 2018 with introduced, native and introduced/native perennial grass seed mixes using a no-till drill. Establishment of perennial grasses in each seed mix was significantly higher in *Imazapic* fall treated plots. Fall plots recorded 21.5, 8.6 and 17.2 perennial grasses/m^2 in the introduced, native and introduced/native seed mixes respectfully. *Imazapic* spring treated plots recorded 7.5, 3.2 and 7.5 perennial grasses/m^2 in the same seed mixes, respectfully. The *Imazapic* spring treated plots continued to show cheatgrass control in the spring of 2019, 1 year following application which is another indicator that this non-selective, soil-active pre-emergent herbicide has the residual effect to cause additional mortality to seedlings of seeded species. The cold desert environments of northern Nevada rangelands receive the vast majority of its' precipitation during the winter months, spring applications of *Imazapic* in environments that receive warm season precipitation may experience less perennial grass mortality than cold desert environments of northern Nevada.

Initial Seeded Perennial Grass Emergence Following the Application of Rejuvra™

Charlie Clements, Dan Harmon

USDA-ARS, Reno, USA

Abstract

The accidental introduction and invasion of cheatgrass (*Bromus tectorum*) throughout millions of hectares of Intermountain West rangelands has resulted in astronomical changes to many plant communities. Resource managers need tools to conduct aggressive and effective weed control practices on cheatgrass-infested rangelands to improve restoration/rehabilitation efforts. The use of pre-emergent herbicides can be very effective in decreasing cheatgrass densities that limit establishment of perennial species. *Inazaflam*, Rejuvra™, is a pre-emergent herbicide recently available for research on Nevada rangelands. In 2018 we initiated research to measure the efficacy of Rejuvra on cheatgrass control and perennial grass emergence in northern Nevada compared to the widely used pre-emergent herbicide, *Imazapic* Plateau®. Due to the environments of the cold desert, we applied these pre-emergent herbicides in the fall of the year, fallow the site for 1-year and then seed with desirable perennial species. Rejuvra plots reduced cheatgrass initial densities by 94.8%, while Plateau plots reduced cheatgrass densities by 97.8%. Following 1-year fallow, treated plots were seeded in the fall of 2019 to introduced native and introduced/native seed mixes using a no-till drill. In the spring of 2020, Rejuvra plots recorded significantly less initial emergence of perennial grasses in each seed mix compared to Plateau treated plots. Plateau plots recorded 16.7, 4.8 and 17.7 perennial grass seedlings/m² in the introduced, native and introduced/native seed mixes, respectfully. Rejuvra plots recorded 1.6, 0.5 and 5.9 perennial grass seedlings/m² in the same seed mixes. Amount and periodicity of precipitation is critical for germination and emergence, yet the site only received 14.38cm of precipitation from October 2019 through September 2020. It is also reported that Rejuvra may have a longer activity than the 12-15months reported for Plateau, therefore, we set up-2-year fallow plots to test perennial grass emergence in additional Rejuvra treated plots.

Susceptibility of Native Annual Forbs to Indaziflam and Imazipic.

Dan Harmon, Charlie Clements

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Abstract

Management techniques to minimize the negative impacts of exotic plant invasions can include a diverse array of tools. One such tool is the use of pre-emergent herbicides. These herbicides, if used correctly, pose little threat to established perennial plants and are extremely effective on young seedlings. The primary target for most rangeland pre-emergent herbicides is annual grasses. However, the unintended costs to native annual forb populations has not been well studied. Broadleaf native annual forbs likely vary in their susceptibility to different pre-emergent herbicides. Annual forbs have complex seed dormancy strategies that lead to persistent seed-banks that may outlast the herbicide activity period. Imazipic has about a 1-year activity period, which can vary depending on environmental conditions. The recently developed herbicide indaziflam has a longer activity period beyond 1 year. We designed a field experiment to evaluate the susceptibility of native annual forbs to these herbicides. At two field sites in northern Nevada, we seeded replicated plots ($1m^2$) of 5 different native annual forbs. Plots were seeded October 2019 on (1) non-herbicide treated plots, plots 1 year after (2) imazipic and (3) indaziflam treatments (sprayed September 2018) and plots the same year as (4) indaziflam application (sprayed September 2019). Monitoring occurred in May 2020. Overall, the reduced cheatgrass competition and decreased herbicide activity on imazipic plots lead to the greatest forb establishment densities (2018 imazipic: 83 seedlings/m^2, non-herbicide: 34 seedlings/m^2, 2018 indaziflam: 7 seedlings/m^2, and 2019 indaziflam: 0.5 seedlings/m^2). These results indicate that indaziflam is remaining active the second year after application, however some seedling establishment did occur, demonstrating the potential to replenish the annual forb seed-bank for long term persistence. Replicated plots were seeded in October 2020 and monitoring will continue on previous and newly established plots to determine the long-term effects of these herbicides on native annual forbs.

The Effects of Competition, Transplant Age, and Timing of Planting on Success of Wyoming Big Sagebrush Transplants.

Corinna Holfus

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Abstract

The increased prevalence of annual grasses such as cheatgrass (*Bromus tectorum* L.) in the sagebrush steppe ecosystem has led to an increase in fire frequency and intensity. These fires wipe out the native bunchgrasses and sagebrush leaving niches open for more cheatgrass to invade, creating a positive feedback mechanism that decreases the probability of sagebrush naturally re-establishing. The use of traditional reintroduction methods such as drill seeding and broadcast methods to re-establish sagebrush have proven to have lower success rates than the use of a new alternative, seedling transplants. However, the exact timing of planting, risk of competition to seedlings, and age/size of seedling when planted is not known and warrants further testing. This study measures the effects of timing of planting (fall or spring), age of transplant when planted, and competition with annual invasive grasses of Wyoming big sagebrush (*Artemisisa tridentata* ssp. *wyomingensis*) transplants by looking at survival rates in the spring and late summer as well as volume of surviving shrubs. According to the first-year preliminary results, transplants 10 weeks and older had higher survival rates compared to the youngest age classes. There was no difference in overall survival among age classes between the age of 10 weeks to 6 months ($p < 0.05$). Additionally, transplants planted in the spring had higher survival rates than transplants planted in the fall ($p < 0.05$). Competition with annual grasses decreased volume and overall survival compared to transplants planted in a bare ground, no-competition landscape. This study improves our knowledge on the use of Wyoming big sagebrush transplants and how to utilize this method for restoration use.

Using Deep Furrows to Improve Seeding Success in Bromus tectorum Invaded Areas

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Abstract

Bromus tectorum is an invasive annual grass that has rapidly invaded and transformed the Great Basin region of North America, particularly in native sagebrush and perennial grass systems. Restoration of these invaded sites has been met with low levels of success. Pre-emergent herbicide is a proven means to control annual invasive grasses, like *B. tectorum,* but typically does not allow for concurrent seeding of desired species. Once the effects of the herbicide decline enough to seed, conditions also become favorable for weed species to return and outcompete the seeded species. Deep furrowing may be a method to concentrate pre-emergent herbicide away from seeded species and place the seed in a microsite that has improved soil moisture and temperature conditions to enhance plant survival. In this study, we analyzed the effectiveness of deep furrows to enable simultaneous spraying of imazapic and seeding of two bunchgrass species, *Psuedoroegneria spicata* and *Agropyron fragile.* We found that the deep furrow treatment, in combination with imazapic, decreased weed competition on seeded species. For plots sprayed with imazapic, deep furrows increased seedling density by twice as much as compared to planting in shallow furrows. Overall this research provides evidence that deep furrows in combination with imazapic are a potential restoration approach to establish perennial vegetation in areas transformed into *B. tectorum* monocultures.

Variety Selection of Six Common Tallgrass Prairie Species for Restoration in Northeast Texas

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Abstract

Native tallgrass prairies are a threatened ecosystem. The rich diversity of tallgrass prairies provides important ecosystem services that should be preserved through enhanced restoration. The first step in ecosystem restoration is the selection of locally-adapted seed sources—and this information is lacking in northeast Texas. We planted 30 varieties of native grasses using 13 common native tallgrass prairie species on 630 plots on approximately one square kilometer on a Red River floodplain in Fannin County, Texas. Six of the 13 species had more than one variety planted, with genera including *Bouteloua, Tripsacum, Andropogon, Sorghastrum, Panicum,* and *Schizachyrium*. We compared the density of varieties within a single species to determine which variety is most suited to grow in northeast Texas. First-year establishment results show Coastal Plains *Schizachyrium scoparium* and Earl *Andropogon gerardii* to be most successful in their genera. There were no differences among varieties of the other four genera. Further monitoring is needed to document establishment dynamics and evaluate future restoration success.

Establishment of Sagebrush for Restoration of Agricultural Lands

Liz Bailey, Eric Thacker, Kari Veblen

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Abstract

A need for reestablishing sagebrush in disturbed landscapes across the Western United States has been identified but traditional restoration methods, primarily seeding, have been largely unsuccessful. Abandonment of agricultural lands is expected to increase in the American West and research is needed to determine the best techniques for restoring these lands. To improve establishment outcomes, there has been increased interest in the planting of containerized greenhouse plants, or "tubelings", and to a lesser extent transplanting mature plants, "wildlings", from nearby stands or gardens. Tubelings and wildlings have yielded high rates of establishment but it is unknown whether the success rates from these methods are high enough to offset the differences in associated cost. In this study we tested three different methods for establishing mountain big sagebrush (*A. tridentata* ssp. *vaseyana*): broadcast seeding, planting greenhouse "tubelings", and transplanting "wildlings". This research was conducted on Fox Hills Ranch in Southeastern Idaho which has a land-use history of livestock grazing and was dominated by two intentionally introduced grasses, Smooth brome (*Bromus inermis*) and Kentucky bluegrass (*Poa pratensis*). Tubeling height, crown, vigor, and planting quality were assessed at the time of planting, and both tubelings and wildlings were assessed after the first winter, in June 2020, and after the first pronounced dry period, in October 2020. Survival of wildlings in October 2020, one year after planting, was significantly higher than that of tubelings (90% and 20% respectively). Poor planting quality, which was noted when a plant had exposed roots or air pockets in the soil at time of planting, was significantly associated with tubeling mortality. The results of this study support previous findings that wildlings can yield high survival rates and suggest that, when conditions are appropriate, wildlings may be a cost-efficient method for establishing sagebrush.

Interseeding Shrubs on Grass Dominated Mule Deer Winter Ranges Using a Scalper

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Abstract

Critical browse species have been lost on many important mule deer winter ranges due to fire and other disturbances. These foothill habitat are now occupied by competitive perennial grasses in some cases and by invasive annual weed in others. Difficult terrain also reduces treatment options for restoring browse to these winter ranges. We looked to revive some older technology to interseed browse onto these sites. We modified a D5 dozer to scalp away existing vegetation and to simultaneously seed browse seed into a furrow. Broadcasters were also added to seed small seeded shrubs such as big sagebrush and forage kochia. This dozer is able to seed into competitive perennial grass stands on steeper slopes, while reducing competition for seedlings, and creating a water catchment. This new scalper has been used on many Wildlife Management Areas throughout northern Utah in recent years.

Improving Dryland System Restoration with Novel Fungicide Seed Coating Technologies

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Abstract

Direct seeding is a cost-effective pathway to restore degraded ecosystems; however, dryland systems characteristically experience low seedling establishment, with failure typically occurring during early life stage transitions (germination, emergence, and establishment). Many fungi present in rangeland soils are pathogenic to native seeds, resulting in seed and seedling mortality and plant recruitment failure. Fungicide seed coatings used in the agriculture industry for decades have been successful in overcoming these biotic bottlenecks. However, the use of seed technologies is relatively novel in rangeland restoration. Our study set out to evaluate seed viability and germination, seedling emergence, and the successful establishment of native seed coated with a targeted fungicide formulation. We designed a fungicide formula that has been shown to successfully control fungal pathogens of the native bunchgrass *Pseudoroegneria spicata* in a laboratory setting. In 2017 and 2018, treated seeds were sown at six big sagebrush ecological sites across the Great Basin, U.S.A. We observed the fungicide seed treatments at all sites to maintain viability longer and a 20 % increase in germination over the non-treated seed. Treatment effects on emergence and establishment over untreated seed varied by location; however, when averaged across the Great Basin, treatments increased emergence by 46 % and bunchgrass establishment by 97 %. Fungicide seed treatments appear to have the potential to overcome the barriers to successful restoration caused by fungal pathogen attacks.

Seedling Defoliation Can Influence Survival of Perennial Grasses in the Great Basin, but Timing matters

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Abstract

Restoration of dryland ecosystems is often limited by low seedling establishment and survival. Defoliation caused by insects and small mammals could be an overlooked cause of seedling mortality. In the sagebrush steppe we tried to determine how common herbivory of grass seedlings is and how influential it is on the success of restoration efforts in a series of three experiments. We examined how controlled defoliation influenced seedling growth and survival in a greenhouse and in a field setting, comparing outcomes between seedlings that received no defoliation, 30% defoliation, 70% defoliation, and those defoliated either once or twice. In the greenhouse, seedlings proved most sensitive to repeated 70% defoliations with several species showing reductions in root growth under this treatment, with higher mortality additionally for *Poa secunda*. Surprisingly, in the follow up field experiment, several species, *Psuedoroegneria spicata* and *Agropyron crisatum*, actually displayed increased survival after some defoliation treatments. Findings from our third experiment, a large-scale observational study observing naturally occurring herbivory on reseedings throughout the Northern Great Basin, may help elucidate the apparent contradictions between our first two studies. We found that defoliation occurring early in the growing season, directly after the seedlings had established had a small positive effect on survival probability by the end of the growing season. However, herbivory occurring later in the growing season, particularly about a month and a half after emergence negatively affected survival. Seedlings of our perennial grasses seem quite resilient to the effects of herbivory, perhaps because they are still drawing resources from their seeds. Once plants become juveniles, they seem more susceptible to the detrimental effects of tissue removal. Insects appeared to be doing the majority of the damage because survival was overall higher in our mammal insect exclosures than in our control or just mammal exclosures.

Staggered Seed Trial for Rangeland Restoration

Brianna M. Slothower[1,2], Anthony Falk[3,1], Sandra Rideout-Hanzak[1,2], Terry Blankenship[4], David B. Wester[1,2]

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Abstract

Over fifty percent of US rangelands contain introduced, exotic plants. Proposed practices aimed at establishing native grassland species while excluding or reducing exotic grasses include mechanical and chemical treatments before seeding, flooding the seedbank with native seeds, and cover crops planted with native seeds. Another approach of restoring grasslands from a retired crop field involves seeding a low-diversity, highly competitive seed mix. We are extending this approach to restore a pipeline right-of-way that is dominated by old world bluestems (*Dichanthium spp.*) and Bermuda grass (*Cynodon dactylon*) in south Texas. We chose three locally-adapted, native seed mixes comprised of either 3 species, 5 species, or 11 species. Each mix is seeded at a rate of 20 pure live seeds m^{-2} to test the hypotheses that (1) seed mix diversity is effective in reducing density of exotic plants that emerge from the seed bank by (2) increasing diversity of target seeded species. Early emergence (< 3 mo post seeding) indicates that neither exotic plant density nor seeded plant density is affected by the diversity of the seeded mixes. Longer-term monitoring will reveal how future establishment dynamics affect species composition on the restored pipeline.

Riparian & Meadow Ecosystems

Wet Meadow Habitat Responses to Variation in Grazing Management Practices: Balancing Habitat Requirements of Greater Sage-Grouse with Livestock Production

Kenneth Randall[1], Melinda Ellison[2], Tracey Johnson[3], Joel Yelich[2]

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Abstract

In the arid western United States, wet meadows provide water and forage used by wildlife and domesticated livestock. Because wet meadows comprise a small proportion of the overall landscape, proper management of this limited resource is essential. Greater sage-grouse (*Centrocercus urophasianus*), an Idaho Species of Greatest Conservation Need, depend upon particular species of forbs, hereafter preferred forbs, found in wet meadows during brood-rearing. Our objective was to determine how differences in grazing timing and intensity influence sage-grouse preferred forbs and livestock performance in wet meadows used for brood-rearing by sage-grouse. To evaluate associations between livestock grazing and plant communities, we established pastures (n = 15 total pastures) in wet meadows at Rinker Rock Creek Ranch in south-central Idaho and stocked them with yearling heifers during 2019 and 2020. Heifers grazed six pastures in June (early-season; 16 days) and six pastures in August (late-season; 16 days) at moderate (30-40%) and high (70-80%) relative utilization levels (n = 3 pastures per treatment). Three pastures provided un-grazed controls. To compare short-duration grazing with continuous grazing management typical of the region, three wet meadow pastures received continuous grazing treatments to achieve an overall utilization of 60%. Measurements of plant community attributes and heifer performance occurred before and after grazing (< 7 days). Average (± 95% CI) cover of sage-grouse preferred forbs ranged from 0.83 ± 0.33% in control pastures to 28.31 ± 15.76% in continuous pastures. Average (± 95% CI) daily gains of heifers varied from 0.68 ± 0.15kg per day in high-intensity grazing during the late-season to 1.05 ± 0.15kg per day in moderate-intensity grazing during the early-season. We will present analysis of grazing effects on plant communities and livestock performance. Results will address the viability and impacts of multiple grazing strategies on wet meadow habitats shared by sage-grouse and livestock.

Using Grazing Timing and Duration to Manage Water Quality in Rangeland Streams

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Abstract

Balancing cattle grazing with water quality is a key management goal across the US West. Currently, rangeland managers debate whether practices such as rotational grazing provide measurable benefits for livestock and conservation outcomes. Because of this, a common way to address poor water quality is to remove cattle from riparian areas. To explore management solutions other than removal, we examined how cattle presence plus two elements of rotational grazing - the length of time cattle spend on rangeland (i.e., duration), and the season grazed (i.e., timing) affected stream *Escherichia coli* (*E. coli*) concentrations via a multi-year, landscape-scale observational study. *E. coli* is a fecal bacteria that can sicken people and is thus a common indicator of rangeland water quality. We also modeled how grazing duration and timing affected the ability to meet regulatory benchmarks for *E. coli* throughout a grazing season. We found that grazing duration controlled the length of time *E. coli* concentrations were high in streams. In short- and medium-duration systems, *E. coli* concentrations were high for shorter timeframes (15-20% of the season) than in long-duration systems (50% of the season), resulting in fewer violations of national and state water quality standards. Stream *E. coli* concentrations also showed a consistent seasonal pattern, starting with lower concentrations in spring, peaking in summer, and declining towards fall. As a result, grazing during the spring or fall, rather than summer, reduced the number of days that *E. coli* levels exceeded water quality standards. Our results suggest that reducing the duration of grazing period and shifting its timing may be effective strategies to mitigate water quality impacts without fencing streams from cattle or entirely removing cattle from rangeland pastures with streams. Ultimately, grazing duration and timing offer managers two tools beyond cattle removal to manage water quality in rangeland streams.

Low-Tech Process Based Restoration in Prairie Systems: A Test and Demonstration Project in Western South Dakota's Headwater Prairie Streams

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Abstract

Western South Dakota's prairie streams and riparian systems are one of the most biologically important yet heavily utilized features of our landscape. They are deeply incised and disconnected from adjacent floodplains, which causes water to quickly leave the landscape resulting in an overall loss of hydrologic function. Due to this impaired condition, many of these systems are void of riparian vegetation and are unable to slow and hold water on the landscape – especially in times of heavy rainfall or severe drought. The Nature Conservancy in partnership with the NRCS, BLM, Pheasants Forever and South Dakota State University has begun work on a test and demonstrate project to install, monitor and evaluate low-tech process based restoration (LTPBR) techniques to better understand how these principles can be applied in our landscape and across the Northern Great Plains. The goal of this project is to create an understanding, awareness, and interest in utilizing low-tech, low-cost restoration solutions that can be readily implemented by landowners at scale, and to evaluate how effectively low-tech riparian structures restore riparian functions in prairie streams. Our first field season focus has been on installing beaver dam analogs (BDA) and Zeedyk rock structures. Throughout this project we are interested in better understanding the potential of prairie riparian corridors and providing landowners with novel and cost-effective riparian restoration solutions.

Soil Carbon Response to Grazing Intensity on Nebraska Sandhills Meadows.

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Abstract

Soils are the major terrestrial reservoir of carbon and nitrogen. More sustainable land management practices have the potential to offset about one-third of global annual greenhouse-gas emissions. However, little is known about how management affects the storage, dynamics, and physical stability of soil carbon in temperate grasslands. We evaluated the influence of eight years (2010–2018) of low and ultrahigh stocking density rotational grazing treatments on surface soil organic carbon (SOC; 0–10 and 10–20 cm) in the Nebraska Sandhills. We set a 25-ha complete block design experiment on a sub-irrigated meadow, applying four management treatments: ultrahigh stocking density (Mob), 4-pasture rotation with one grazing cycle (4PR1), 4-pasture rotation with two grazing cycles (4PR2) and annual haying (Hay). We used a fixed stocking rate for all treatments, having stocking density as a variable. We used mixed-effect models to analyze the data. On average, SOC at 0–10 cm ranged from 2.29 to 3.07 and at 10–20 cm, from 0.45 to 0.80 g $100g^{-1}$. In 2018, there was no significant difference in SOC between treatments at either depth. Although grazing treatments did not affect total SOC content, they did influence the proportion of SOC at each depth and aggregate fraction size (<0.052, 0.053–0.5, >0.5 mm). 4PR2 and Mob treatments resulted in 10 and 19% lower SOC, respectively, in smaller-sized aggregate fractions at the 0–10 cm depth, but 300–467% higher SOC for 4PR2 and 1.56–67.75% higher SOC for Mob treatment in medium and large aggregate fractions at the 10–20 cm depth compared to Hay and 4PR1 treatments. Eight years after grazing, the more intense rotational grazing led to higher SOC content in the larger aggregate size at both depths, but no increase in SOC in the smaller aggregate fraction, where SOC is expected to stabilize.

Mink Creek Water Quality - an E.coli Mystery Solved With DNA

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Abstract

The United States National Forests are mixed-use lands that support human recreation and cattle grazing. Overuse by humans or cattle, however, can lead to the fecal contamination of local waterways. Until recently, the source of these contaminants was a subject of conjecture; however, microbial source tracking tools have become widely used and are proving to be a valid methodology to identify the contamination source. This study analyzed the quantity and sources of fecal contamination in the Mink Creek watershed in southeastern Idaho. The U.S. Forest Service Caribou-Targhee National Forest (USFS) manages this watershed, and previous research indicated that some localities within the watershed exceed US EPA standards for coliform bacteria. In 2019, water samples were collected before livestock began grazing and throughout the spring, summer, and fall after livestock grazing had ended. Fourteen sites were sampled seven times during the field season, allowing the water to be analyzed for total coliforms and *E. coli* bacteria. Microbial source tracking techniques using *Bacteroides* bacteria, which are known to live in specific digestive tracks, were used to identify the source of *E. coli* at each sampling location. The analysis indicated that *E. coli* counts exceeded state regulatory limits 35% of the time. These exceedances were associated with DNA source tracking markers for cattle (5.9%), human (58.8%), or both cattle and human (5.9%). Unknown sources were responsible for the *Bacteroides* bacteria 29.4% of the time.

Upland Meadow Phenology: Grazing Effects and Their Influence on Sage-Grouse Food Sources

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Abstract

Riparian and ground-water dependent ecosystems found in the Great Basin of North America are highly biologically diverse and productive. These environments are heavily utilized by wildlife throughout the year, especially during the late spring/early summer months. Greater sage-grouse chicks, in particular, are dependent on forb communities and arthropods from these areas to provide food during the first several weeks after hatching. Grazing is a major influence on many riparian complexes in rangelands, and high levels of grazing pressure commonly occur throughout the Great Basin. Understanding how factors such as intensity and timing of grazing affect when environmental resources are available is important for land management. Grazing has the potential to shift when plant and insect communities begin their season of growth, reach their peak of season, and finish their season. This may desynchronize when key wildlife species need access to these resources and when these resources are available. Four upland meadows were fenced in the fall of 2019 within the Desatoya Mountain Range in Nevada. Three of the four meadows were split and half of each meadow was left ungrazed while the other half was grazed to a stubble height of 10 cm over a three-day period by cattle in mid-June. The fourth meadow was unmanaged and allowed to be utilized throughout the entire season. Height and phenology data (when plants began to grow, reached their reproductive stage, developed seed, began to desiccate, etc.) were gathered from the plant communities semi-monthly from May to September in 2019 and 2020. Additionally, near-surface digital cameras (phenocams) were established at every meadow to further monitor plant growing cycles. We found a correlation between how these meadows were grazed, and when plant communities reached various life stages. Also, we found that the addition of phenocam Green Chromatic Coordinate (GCC) further strengthened that correlation.

Ranchers, Beavers, and Stream Restoration on Western Rangelands

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Abstract

The past decade has seen a rapid rise in beaver-related stream restoration (BRR) using beavers and beaver dams (real or artificial). Potential benefits of this restoration approach include restoring aquatic and riparian habitat and recovery of threatened species dependent on it, improving water availability and stream flow regulation, reducing erosion and stream incision, and climate change adaptation. These services are particularly important in rangelands of the western United States, where climate change is predicted to increase aridity and reduce net primary productivity – decreasing the quality and quantity of forage for livestock and productivity of riparian systems. But little is known about the human dimensions of BRR, and what is needed to create a supportive social environment for implementing it on western rangelands. To help fill this gap we examined six BRR projects in three states that included both public and private rangelands where ranchers graze livestock. We examined how beavers, beaver dams, and BRR affect ranching operations; how ranchers view beavers, beaver dams, and BRR; the policy context for BRR; and how ranchers and other stakeholders can work together for successful implementation. We found that ranchers in our study reported both positive and negative impacts of beavers, beaver dams, and BRR on their properties and livelihoods, but largely perceived the benefits to outweigh the drawbacks. We also identified six social factors important for creating a supportive social environment for BRR: 1) ranchers who perceive the benefits of beavers, beaver dams, and BRR to outweigh the drawbacks; 2) education and assistance to help landowners adopt non-lethal mitigation techniques for nuisance beavers; 3) grazing practices compatible with BRR; 4) low harvest pressure on beavers; 5) a regulatory environment that enables experimentation, flexibility, and adaptive management; and 6) proponents, ranchers, and partners willing to take risks, innovate, be flexible, and stay committed.

US Forest Service National Riparian Areas Base Map

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Abstract

Riparian areas are transitional zones along waterways and wetlands that contain unique geomorphic, soil, vegetation and hydraulic characteristics which support irreplaceable values and multiple ecosystem functions. These characteristics explain how riparian areas respond to disturbance.

Collaboration and stewardship of these biodiverse areas has become a focus for the USDA Forest Service. The 2012 Planning Rule required that riparian areas be addressed in new land management plans. During the past five years, the Forest Service finalized a national context for delineating and quantifying riparian areas. This Riparian Area Delineation Model (RBDM) v5.x uses a variable width valley approach and relies on freely available data from USGS, NRCS and others to map these dynamic areas.

The model and national map are also being sought by national, state and other partners to support watershed assessments, flood zone identification and more. Here we present a national riparian areas base map, the associated model and selected analysis such as land cover change in riparian areas. Ongoing work includes mapping in Alaska, incorporating newer data, and a publication.

These data support the Forest Service 2012 Planning Rule and they can do so much more. There is broad value for multi-scale work in monitoring, management actions, and policy decisions with partners across the country. Nutrient management, flooding, land use and land cover change are on all of our minds. In sharing this information, we hope to increase collaboration on land management decisions to maintain and improve riparian area ecological condition and function.

Socio-Economic-Ecological Systems

Defining and Measuring Success of Collaborative Efforts: Lessons Learned from the Results Oriented Grazing for Ecological Resilience (ROGER) Group's First Five Years

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Abstract

Collaborative approaches have been broadly promoted as promising ways to deal with complex and often contentious natural resource issues. Although various efforts share broad similarities, no single framework or prescription defines collaboration. Rather, collaborative arrangements are typified by shared characteristics that manifest in different configurations according to the place-specific context. As a result, while some shared foundational principles and practices exist, there is not a recipe or one-size fits all approach to defining and measuring success.

The diversity of collaborative processes and outcomes pose a challenge for evaluation. In response to this, scholars have experimented with evaluation frameworks that identify a mix of process characteristics and first-, second- and third-order outcomes (Smedstad, J., & Gosnell, H., 2013). One such framework is the Partnership Impact Model™ (PIM) developed by the One Tam Collaborative in California (Mickel, A. E., & Goldberg, L., 2019). The PIM outlines eleven partnership impacts (foundational, operational and outcome) that landscape-scale stewardship partnerships should consider when it comes to delivering, measuring, evaluating, and communicating the value of their collaborative initiatives – based on what impact looks like for them. It is a tool to help generate, scale up, and sustain impact throughout the partnership lifecycle.

This presentation will review lessons learned from the application of the PIM to the Results Oriented Grazing for Ecological Resilience (ROGER) Collaborative five years in. ROGER is a rancher-led collaborative focused on achieving land management objectives that conserve sagebrush ecosystems and support ranching in Nevada and the Great Basin through outcome-based and targeted grazing; experimentation with adaptive management; the strategic use of grazing pre- and post-fire; and the development of effective and efficient assessment, monitoring and planning tools at both a site and landscape scale.

Comparison of Ranchers' and BLM Specialists' Ecological Indicators in Southern Idaho.

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Abstract

The Bureau of Land Management (BLM) manages over 12 million acres of public lands in Idaho, and more than 1,600 livestock producers share the management of that land through their grazing permits. Both ranchers and public land managers make observations about the land that inform their management decisions. Understanding the local knowledge of Idaho ranchers and BLM specialists, including the ecological indicators that they look at and use for rangeland management in the semi-arid landscape of southern Idaho, can help us identify how managers respond to and interact with the ecosystem. Understanding the relationship between management decisions and the ecosystem will be increasingly important as variability in ecological conditions is likely to increase with climate change. Through qualitative analysis of semi-structured interviews conducted with ranchers and BLM specialists throughout southern Idaho, we compared the ecological and operational indicators interviewees observe. Preliminary results suggest that both the ranchers and the BLM specialists place importance on observing perennial grasses, grass phenology, and plant life stages. However, these groups differ in how they observe and consider livestock behavior, soil conditions, and annual grasses. When making management decisions, ranchers are highly responsive to environmental cues, and BLM specialists acknowledged ranchers as a source of information about the land. Our work indicates that ranchers have ecological knowledge that can contribute to the discussions on how to allow more flexibility in public lands grazing and adapt rangeland management to a changing climate in Idaho. Comparison of managers' preferred ecological indicators provides insight into the ecological and operational considerations that are going into rancher and BLM rangeland management and provides information for improved flexibility and communication in collaborative rangeland management.

Assessment of Some Factors Influencing Human-Elephant Conflict in Southern Kenya

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Abstract

Increasing human populations and changes in land use have brought increased competition for space and resources between people and wildlife in the Amboseli Ecosystem. Among all large mammal species, elephants are one of the most vulnerable to land use change due to their home range and seasonal migrations. The ensuing interactions due to sharing resources are frequently negative and the individuals involved progressively develop negative attitudes towards elephants, viewing them as a risk to their survival. This research attempted to analyze land use and cover changes (LULCC) as well as human perceptions as some of the factors driving human-elephant conflict in Mbirikani for improved management and coexistence of elephants and local communities. LULCC were analyzed from multi-temporal cloud free Landsat Thematic Mapper data of 1987, 1999, 2013 and sentinel for 2020 using QGIS 3.12. Percentages of land area were computed to make comparisons of the changes in LULC over time while Chi square goodness of fit was used to establish whether the changes were significant. Household surveys were used to collect data on attitudes and perceptions as well as the nature and extent of human-elephant conflicts. Results showed an increase in conflicts over the years. Crop cultivation was the largest land use change. Crop raiding was the main form of conflict followed by water structure damage with a significant difference between sampling locations at $P< 0.05$. Elephants emerged as the most troublesome wild animals. Maize and tomatoes were most preferred by elephants. Seasonality, time of day and stage of crop growth were key factors for raids. Resource mapping with community revealed significant changes in bushland, woodlands, and irrigated agriculture. Key strategies recommended by the community were fencing, compensation and community conservation. This study calls for urgent action of human- elephant conflict to safeguard community livelihoods and enhance elephant conservation.

Conflict, Collaboration, and Conservation: Multiple Use Management in the Thunder Basin Ecoregion (TBER)

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Abstract

Throughout the western US, managing public lands for multiple uses frequently results in conflict among stakeholders. One such example is the Thunder Basin ecoregion (TBER) of northeastern Wyoming, a rangeland ecotone that exemplifies the intersection of diverse interest groups. In recent history, extreme fluctuations in prairie dog populations have created conflict over management strategies, which stakeholders have attempted to mitigate through collaborative efforts. Prior research has indicated that diverse stakeholder involvement in decision-making can result in holistic solutions, but stakeholders also possess different ways of knowing (WOK) that may limit their ability to develop a shared understanding of the source of the problem and their goals for the landscape. To examine the impact of diverse WOKs on collaborative land management, we use a mixed methods approach to address the following objectives: (1) Examine the ideological diversity of stakeholders involved in collaborative management to determine the role of different WOKs in collaboration, using a qualitative analysis of stakeholder interviews and focus groups; (2) Develop a reproducible workflow to transform complex, undigitized data from natural resource management agencies into usable datasets that are verified and available for public use; and (3) Assess the extent to which different WOKs are being utilized in institutional decisions made by the U.S. Forest Service (USFS) in TBER over time through a content analysis of USFS Records of Decision. Preliminary results from this project suggest that different stakeholders indicate different goals for and relationships to TBER-as-place, making it difficult for collaborators to reach consensus. Findings from this project will provide insights into how land is being managed in TBER in response to environmental risk and diverse WOKs, and how these different sources of knowledge can be effectively integrated into collaborative management. Understanding these factors is critical to our ability to maintain sustainable western livelihoods, communities, and ecosystems.

Risk & Conservation: Exploring the Relationship Between Livestock Producer Risk and Conservation Programs

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Abstract

Ranching in the American West is a risky endeavor often defined by navigating the unknowns of the market and nature. A possible tool to navigating these uncertainties for ranchers may be enrollment in working lands conservation programs. Prior work that analyzes the effect of agricultural risk on conservation efforts has focused primarily on land use conversion and irrigation-based operations. The present study develops context and insight surrounding the relationship between the USDA Environmental Quality Incentives Program (EQIP) and grazing based livestock operations. In this two-part project we first explore the impacts of drought, grass production, and commodity price risk on EQIP grazing practice enrollment for agricultural producers in the High Plains region from 2009-2018. Specifically, we ask how heterogeneous risk exposure at the county level drives conservation program implementation. Early results indicate that drought and price risk both predict drought-based and overall grazing practice implementation at the county level. Second, we analyze a 2013 randomized survey of Colorado and Wyoming ranchers to see how enrollment in EQIP mediates the impacts of drought for sampled ranchers and how producers who enroll in EQIP differ in their management from those who do not. Controlling for demographic, regional, and business characteristics, results indicate that ranchers who enroll in EQIP are more likely to add alternative on-farm enterprises during drought and incorporate pasture rest into grazing system to prepare for drought. Additionally, when faced with drought conditions, ranchers who had enrolled in EQIP were more likely to report impacts of drought on weaning weights and profits. Results from both studies work in concert to provide insight into the relationship between drought, markets, EQIP, and ranching in the American West.

Hunt, Gather, Fish, Graze: Conceptualizing US Public Lands as Food Systems

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Abstract

US public lands support diverse and interrelated food systems. An estimated 46% of all federal land in the US is grazed by cattle; USDA National Forest Service lands in Alaska supply an estimated 48 million fish to commercial fisheries, and over 100 million Americans hunt each year, with many of these hunters harvesting game sustained by habitat on public lands. Yet, while social and ecological researchers have long recognized the importance of U.S. public lands in sustaining community well-being and biodiversity across the rural West, little is understood about how to recognize these values within the context of human food systems. Food systems research is concerned with the economies, lifeways, and cultures associated with all steps of feeding people, including producing, harvesting, processing, transporting, and consuming food. We introduce a conceptual framework for public lands-based food systems in the western US by developing a comparative case study across three major systems on National Forests: a) salmon-fishing-forest subsistence systems in Southeast Alaska; b) large herbivore-hunting-rangeland systems in the arid and semi-arid West; and c) cow-calf-ranching-rangeland based systems in the western Great Plains. Using this approach, we seek to understand the interconnections and interdependencies between ecosystems, human food systems, and rural lifeways across different species, scales, and public/private property regimes. In doing so, we hope to elucidate common vulnerabilities and opportunities for resilience, particularly in the face of rapidly shifting/variable climatic and economic contexts. We conclude by highlighting next steps and needs for transdisciplinary research on this topic.

Lived Experiences of Lakota, Navajo, Hispana y Chicana Women Ranchers in the Western US: Successes, Challenges, and Motivations

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Abstract

Rangeland social science research has 1) largely relied on quantitative survey methods, 2) lacked contextualization and intersectional analysis of socio-political and historical realities that shape rancher decision-making processes, 3) almost entirely overlooked the experiences, knowledges and perspectives of ranchers of color, especially women, and 4) is limited by its political unconscious. These limitations reinforce the harmful dominant narratives that invisibilize our varied lived experiences, ways of knowing, resistance to inter-locking systems of oppression, and the complex socio-political and historical forces that shape our lives and decisions. Contextualized, intersectional qualitative social science research is needed in rangeland social science to understand how the racialized, gendered, classed, and politicized lived experiences of women ranchers of color influence their goals, decision-making processes, and the challenges they face. To address this gap, we conducted 18 semi-structured life history interviews with Lakota, Navajo, Hispana y Chicana women ranchers across five states. Successes important to interviewees included producing healthy animals and high quality meat on healthy rangelands and keeping the ranch financially sustainable and in the family. Interviewees faced challenges including prolonged drought and climate change, financial strains from Covid-19 and volatile livestock markets, holding onto their land, accessing information and navigating discrimination in assistance programs/agencies. Interviewees were motivated to continue ranching by strong ties to their ancestral homelands, a reciprocal ethic of caring for the land as Mother Earth cares for them, and passing their way of life on to future generations. With this study we center the voices, contributions and herstories of Lakota, Navajo, Hispana y Chicana women ranchers, bringing a Chicana Feminist lens and methodology to rangeland social science and addressing a critical knowledge gap. A more deep and nuanced understanding of the experiences of ranchers that this field has historically invisibilized can support more meaningful and equitable outreach and policy.

Social-Ecological Impacts of Invasive Annual Grass Cover and Rural Community Change Over Time in the Northern Great Basin

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Abstract

The resilience of rangeland agroecosystems is complicated by climate, biophysical, and socio-economic stressors. For example, social-ecological impacts of annual grass invasion coupled with fire are well-documented across the northern Great Basin where invading Cheatgrass (*Bromus tectorum*) catalyzes transitions from sagebrush steppe to grass-dominated systems. Resource ecology often dominates perspectives on such stressors facing rangeland management, yet may lack social-ecological context. Contemporary inclusion of social science within rangeland agroecosystem research can improve scientific understanding of environmental change and impacts. For instance: what socio-economic drivers intersect with climate-vegetation dynamics to further complicate or simplify ranch-level decision-making for livestock producers? This study employs a qualitative approach to understand how northern Great Basin producers perceive and adapt to land cover and community change. The objectives are: 1) explore how socio-economic stressors on livestock production intersect with problems and opportunities presented by changes in annual grass cover and rural community structure, and 2) describe producers' perceptions of social-ecological impacts to their livelihoods, rangeland management strategies, and rural communities over time. In February 2020, we conducted semi-structured interviews and participatory mapping with multi-generational ranching families in Idaho, Nevada, and Oregon. We prompted participants to share their experiences and perceptions of the spatial extent of cheatgrass invading their operations and region a generation ago, currently, and what they expect will change for the next generation. Participants also shared their perceptions of rural community change over the same time frames. Findings illuminate how common socio-economic drivers like rural de-population and consolidating/absentee land ownership influence producers' ranch viability and sense of individual and community well-being. This research also lays groundwork for broadening the geographic scope of stakeholder engagement for the Great Basin site within the USDA Long-term Agroecosystem Research network. Strategies for adaptation to land cover and community change and implications for interdisciplinary network science will be discussed.

Agricultural Identities and Rural Change: Applying Identity Theory to the Experiences of Livestock Producers in Northeastern Colorado

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Abstract

Intersecting climatic and societal changes transform the nexus of land-use, livelihoods, and producer identities in northeastern Colorado. For instance, as urbanization and increasing land and water values influence land-use patterns, some ranchers may abandon ranching as a livelihood and lose or change their occupational identity. Identity is one crucial way we classify ourselves (i.e., rancher, mother, and businessperson), which is, in part, defined by occupation. Although a person's identity helps predict decision-making, little research examines how occupational identity influences rangeland management decisions. To address this gap, using identity theory, we deductively analyzed 32 interview transcripts to conceptualize livestock keepers' identities and the associated livelihood decisions, outlining symbols (e.g., land and livestock), meanings (e.g., hardworking), and behaviors (e.g., stewardship decisions). These findings highlight the interrelationship between producer identities and social (e.g., history and way of life) and ecological (e.g., land and livestock) factors. This emergent social-ecological conceptualization of identity highlights the effect of integrated social and ecological changes on people's self-concepts. For instance, while history often presents farmer and rancher as distinct and conflicting identities, participants related their increasingly plural roles with the need to diversify their operations to preserve their way of life. We argue that plural and changing identities offer opportunities for increased inclusion of diverse roles in rural spaces. This research contributes to rangeland social science and rural sociology by refining agricultural identities, such as clarifying how roles relate to land management and livestock husbandry norms. A more nuanced understanding of livestock keepers' identities and their relationship to management decisions can support Extension staff, researchers, and policymakers to develop strategies appropriate for the shifting needs of increasingly pluralizing and diversifying rangeland stakeholders.

Social Perceptions of Southern Arizona Grasslands and the Societal Benefits They Provide

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Abstract

Rangelands provide a myriad of ecosystem services. The capacities of these services may be enhanced or diminished by shrub proliferation. A variety of brush management techniques have been employed to counteract the real and perceived threats of shrub encroachment. Historically, the primary motivation leading landowners and managers to engage in brush management was to increase forage production, yet this single-issue interpretation may be too narrow. For example, increased shrub cover also makes it more difficult to see livestock and hence gather them for health care or grazing rotation. Open landscapes may also promote biodiversity and enhance wildlife-related income streams (e.g. hunting, ecotourism) as well as increase property values. In other cases, water conservation may be a primary factor underlying efforts to regulate woody plant abundance. Brush management can potentially benefit landowners in several ways, but should be tailored around landowner or agency priorities for ecosystem services.

To ascertain the relative importance of suites of ecosystem services, we conducted an image-based survey to measure how diverse stakeholders (i.e. ranchers, rural land owners, academics, and personnel associated with governmental and conservation organizations) viewed different levels of shrub cover with respect to six ecosystem service categories: aesthetics, soil and water erosion prevention, cultural value, biodiversity, recreation opportunities, and ranching. Best Worst Scaling was used to rank the relative value placed on these ecosystem services categories by each stakeholder group. Understanding the similarities and differences in stakeholder group valuation and prioritization of the diverse ecosystem services provided by rangelands can help target, refine and customize management efforts to meet desired conservation objectives and objectively justify the high economic cost of brush management.

"Governing the Commons:" Beliefs, Values and Group Cohesion in the Sheyenne Valley Grazing Association

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Abstract

This organizational analysis of the Sheyenne Valley Grazing Association, McLeod, N Dak, uses surveys, interviews, letters and transcripts of public presentations for a linguistic analysis, discovering that certain basic values have been prioritized over the 80-year history of this organization. Comparing these results with the conclusions from Elinor Ostrom's "Governing the Commons: The Evolution of Institutions for Collective Action," suggests that this organization has incorporated three (3) additional values which form their approaches to contractual relationships and internal decision-making, and have contributed largely to their stability, group cohesion, long-term success and contribution to the conservation of the unique resource that is the 70,000-acre Sheyenne Valley National Grassland. Actions which promote the health of the land, provide assistance to other members, and that this caring for the land and others are both accomplished with a mind to the well-being of future generations are the foundation for the governance guidelines of this cooperative association of @85 members.

Evaluating Factors that Motivate Private Investment in Grassland Protection and Improve Grassland Productivity in Northwestern China

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Abstract

In the Qinghai-Tibetan Plateau region of China, livestock production relies heavily on grassland quality and some traditional livestock production has seen increasing joint operation and investment in grassland protection to stabilize production. To examine how joint operation of livestock production influences production scale and investment in grassland protection, we used data from the Qinghai-Tibetan Plateau Livestock Production Survey administered by Lanzhou University in 2016 and 2017. Five representative provinces were randomly sampled with 382 and 182 producers, respectively, in the two years. The results showed that among the 664 farmers, about 26% had joint operation; the average production scale was 236 sheep units per household; the average investments for cultivating pasture, installing fence, building greenhouse, and buying forage were 3450, 230, 1867, and 289 RMB per household. Econometric results showed that the factors significantly increasing production scale included joint operation, enduring drought and heavy snowfall, as well as larger grassland area. Variables increasing the investment included joint operation, government funding assistance, heavy snowfall, more owned grassland, and less spatial heterogeneity. This suggests that joint operation increases farmers' investment to improve grass quality and quantity. Similarly, less spatial heterogeneity facilitates making investment in grass production and increasing livestock output.

Enhancing Livestock Production Efficiency in the Qinghai-Tibetan Plateau of China: Insights from an Economic Analysis

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Abstract

In the Qinghai-Tibetan Plateau region of China, enduring winter drought and snowfall threaten some traditional livestock production. To achieve sustainability of livestock production, production efficiency may be improved to further increase the carrying capacity and improve livestock output. To investigate economies of scale and production efficiency of livestock production, we built a dynamic model and showed impacts of factors affecting economies of scale and livestock production efficiency. We used a dataset from Qinghai-Tibetan Plateau Production Survey administered in 2016 and 2017. Among the 664 herders, the average herd size was 236 sheep units per household and the average production efficiency was 9 sheep units per hectare of grassland. Econometric results showed that at the farm level, factors significantly increasing economics of scale included joint operation, enduring winter drought and snowfall, and larger grassland area. This indicates joint operation can be adapted as a means of mitigating climate risks and improving livestock production. Variables significantly increasing the production efficiency included joint operation, government funding, heavy snowfall, more grassland owned, and lower spatial heterogeneity. This suggests joint operation improves livestock production efficiency. Government funding promotes herders to raise livestock more efficiently and enables herders to produce at a high efficiency level.

Conservation Management Models: Identifying Elements of Conservation Leases and Land Management Styles That Promote Wildlife Abundance Using Community Engaging and Capacity Building Surveys That Are Resilient and Scalable.

Laura Diakiw

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Abstract

The Olderkesi Wildlife Conservancy (OWC) in southern Kenya has long been home to both abundant wildlife and pastoral Maasai raising large herds of cattle, sheep, and goats. Both wildlife and pastoralists have benefited from connectivity within the Greater Maasai Mara Ecosystem and barriers to movement threaten the resilience of this long-coupled human-wildlife system. Declining biodiversity as well as fragmentation and loss of wildlife habitat is of growing concern to the Maasai. At the same time, a growing human population and a desire to improve quality of life are driving wildland conversion and unsustainable mortality of wild plants and animals. The OWC has implemented a conservation management model of leasing land and making payments to the local Maasai to keep their land open for wildlife movement and rangeland conservation. With the OWC, the Maasai retain ownership their land but by ceding some of their land rights, the landowner "leases" rights to another entity, such as a land trust, and in the case of OWC, the Cottars Wildlife Conservation Trust (CWCT). By implementing community land leasing, livelihoods can be promoted while significant gains for wildlife conservation in the area may accrue either directly through provisioning of wildlife habitat or migration corridors or indirectly as a buffer for neighboring protected areas. Quantifying the effect of conservation leasing and various land management styles on wildlife populations remains a critical step for validating the conservation management model's as a viable strategy for limiting biodiversity loss. Further, it is unclear whether the impacts to wildlife can be quantified in a manner that may improve how effectively the land management model can be deployed. Such a development would be critical for creating a more adaptive conservation management model.

Application of a Conceptual Model of Science Integration into Public Land Decision-Making as a Foundation for Institutional Efforts to Bridge the Science-Management Gap

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Abstract

Federal agencies manage approximately one-third of U.S. rangelands. Agencies are committed to using science to inform planning and management decisions. Consideration of relevant science information is critical for comprehensive and defensible National Environmental Policy Act analyses. Availability of management-relevant science is influenced by the effectiveness of communication between resource managers and research scientists. Federal land management generally lacks dedicated extension organizations to facilitate management-science communication, leaving scientists and managers to improvise strategies to bridge the science-management gap. The authors developed a conceptual model of science integration into public lands decision-making as a foundation for institutional efforts to bridge the science-management gap. Our model is grounded in the NEPA analysis framework and identifies four types of science information needed: 1) data on resources, 2) science about potential impacts of actions on resources, 3) standard methods for analyzing those impacts, and 4) effective mitigation actions. We applied this model to a stratified random sample of Environmental Assessments completed by the BLM in Colorado between 2015 and 2019 to identify: the actions and resources analyzed; the resources for which direct, indirect, and cumulative effects are quantified; and the resources for which mitigation actions are identified. Preliminary results indicate commonly proposed actions were fluid minerals development, livestock grazing, land transactions, and recreation. The resources most frequently analyzed included terrestrial wildlife, migratory/protected birds, water, soils, vegetation, and cultural resources. Potential effects of proposed actions were most often quantified for terrestrial wildlife and air quality, illustrating best practices that might be applied to other resources. Mitigation actions were regularly identified for invasive plants, migratory/protected birds, and cultural resources. Application of the conceptual model facilitated a structured collaborative analysis of agency decisions, leading to improved understanding and articulation of potential needs for both emerging science and for translating existing science for management application.

Ranchers and Land Managers Want More Research and Extension to Better Manage Rangeland Oaks: Responses to a Survey

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Abstract

From the mid-1980s through 2010, the Integrated Hardwood Range Management Program (IHRMP) created a substantial knowledge base about rangeland oaks in California. Since its dissolution in 2010, there has been less rangeland oak research within the University of California. However, ranchers and other land managers continue to ask questions about how to better manage their oak woodlands and savannas. University of California Cooperative Extension (UCCE) Livestock and Natural Resources Advisors on the Central Coast and Central Valley conducted a survey to identify the highest priority research needs for people managing our oak landscapes. Forty-nine people from across the state filled out the survey. Respondents identified as follows: rancher (22), agency staff (9), academic (2), consultant (2), other (11), unidentified (9). Some people chose more than one category.

The survey asked seven questions, including a question about why respondents thought oaks were important. Four common responses to that question were that oaks provide 1) habitat, 2) shade, 3) beauty, and 4) other ecosystem services. When asked which of three pre-defined topics were most important, 28 people wanted to know how to prevent their oaks from dying; 27 wanted to understand how to increase the number of oaks on their properties; and 18 wanted to know **why** their oaks are dying.

Many questions still need to be answered to help ranchers and other land managers across the state care for our oak ecosystems. Information about invasive species in oak woodlands was the most requested topic, followed by ecological site descriptions, carbon dynamics and climate change in oak woodlands. Now is an opportune time for researchers to develop collaborative projects to fill these research gaps, in addition to conducting workshops to extend existing research developed through the IHRMP.

Adaptive Management to Improve Grassland Productivity and Household Welfare in Northwestern China

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Abstract

Highly variable climate conditions in the northwestern China are challenging livestock production and household income. The continuous grassland degradation is worsened by over-grazing which exceeds the appropriate grassland carrying capacity. As a systematic approach to manage grassland to learning from the outcomes of management actions, adaptive management help farmer better accommodate change, deal with uncertainties, and improve grassland management. This objective of this study is to investigate the influence of adaptive management on grassland productivity and farmer household income in northwestern China. This study builds a conceptual framework based on a systematic literature review and examines the outcomes of adaptive grassland management in the Qinghai-Tibet Plateau region of China. A synthesis of current scholarship suggests significant progress of multiple management strategies including appropriate stocking rate, rotational grazing, estimating forage production and utilization. Policy support also contribute to the success of the management practices.

Towards a Collaborative Rancher-Extension-Research Future: A Case Study from Western North Dakota

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Abstract

Rangelands in the northern Great Plains must sustain livestock production and biodiversity despite a changing climate and persistent land use change. Success requires collaborative efforts between multiple stakeholder groups including ranchers, extension personnel, and researchers to ensure that livestock production and biodiversity conservation do not work at cross-purposes. To investigate solutions for stakeholders and collaborators, researchers must know what questions and issues stakeholders currently face. We interviewed ranchers in North Dakota to determine: (1) how they describe their summer and winter operations; (2) common challenges and threats for their operations; (3) what information and resources they find useful; and (4) their drought management strategies. We conducted focus groups with extension agents and specialists to determine common questions that ranchers ask extension personnel and what information and resources they find most useful for answering rancher questions. We coded the interviews and focus groups to identify recurring themes. We then compared the two groups to determine patterns, commonalities, and disconnects between ranchers and extension personnel. Interviews highlighted that ranchers use a variety of information and technical assistance resources including extension, NRCS, and their local knowledge networks. Ranchers used varying combinations of proactive and reactive drought management strategies like adding classes of livestock, acquiring additional hay, grazing cover crops, and leasing additional acres.

Soil Carbon, Nutrients & Communities

Measuring Soil Nitrogen and Moisture Depletion at a Distance Gradient from Perennial Bunchgrasses

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Abstract

Perennial grasses are the most effective tool for biological suppression and long-term control of the invasive grass, cheatgrass. While the concept of an established perennial grass outcompeting an annual for resources is well known, the mechanisms by which the suppression of cheatgrass occurs involves complex plant-soil interactions. We theorize that perennial grass is depleting the available soil nutrients and moisture to the detriment of cheatgrass, which requires adequate soil moisture to germinate and available nitrogen to support high seedling vigor. The effect is seen on the landscape by the bare soil "suppression" rings that exist around perennial bunchgrasses. The size of the suppression ring can vary based on the species and vigor of the bunchgrass, and the annual weather conditions. Studies by Dr. Robert Blank USDA-ARS and others have measured the decrease in available soil nitrogen within the root-zone of perennial grasses. The most recent greenhouse study conducted by Dr. Blank determined a gradient of soil nitrogen depletion extending from the perennial grass rootzone. We designed a field experiment to examine this gradient. To conduct the field study, we located three stands of perennial bunchgrasses that exhibited cheatgrass suppression. We created a defined edge from the bunchgrass stand by using herbicides to create bare ground. Bare ground was maintained for 2 years prior to sampling to avoid measuring any immediate nitrogen root leaching. Because the sampling area was free of any plants the only moisture or nitrogen uptake that could occur was from the perennial grass. We collected soil at distances of 10cm, 30cm and 80cm from the bunchgrass and measured moisture and available nitrogen. Our results indicated a strong gradient of resource depletion was occurring. The degree of depletion has important management implications for determining desired perennial grass densities on the landscape that would enable long-term cheatgrass control.

Residual Effects of Ivermectin as a Parasiticide on Soil Nutrient Cycling, Plant Biomass, and Dung Beetle Abundance

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Abstract

Grasslands cover 40 percent of the earth's terrestrial area and are critical for agriculture and livestock production. Hence, knowledge of the key ecosystem processes and grassland function is important for global food security. Nutrient cycling in grasslands is closely linked to the decomposition of dung, facilitated by dung beetles with subsequent movement of nutrients into soil and subsequent uptake by plants. Any change in variables can disrupt nutrient cycling and forage production. The increasing use of anthropogenic chemicals in livestock production can alter key controls on decomposition and nutrient cycling. For example, commonly used parasiticides (ivermectin) by livestock producers have been detected in animal dung leading to possible effects on dung beetles which play a key role in decomposition. Slower decomposition delays mineralization of nutrients, reduces soil fertility, resulting in lower plant biomass production. Therefore, we assess the effect of ivermectin in cattle dung on dung beetle abundance, nutrient cycling, and plant biomass production in a South Dakota grassland. In this study, cattle dung with zero, low, and high concentration of ivermectin were placed in grassland in July. Following placement, we monitored the N content of dung, soil, and plants; the abundance of dung beetles, and plant biomass for 63 days. Results suggest the abundance of dung beetles was low in dung with high concentration of ivermectin. Also, the results indicate that dung with zero concentration of ivermectin provided greater inorganic N to the uppermost soil layer. Additionally, the change in soil N did not affect plant N and biomass. In conclusion, residual ivermectin in dung can affect beetle abundance and potentially alter the decomposition rate and nutrient cycling in soil but subsequent effects on plants appear minimal. Future research will examine these same responses to parasiticide earlier in the growing season when plant demand for N is higher.

Exploring the Plant Microbiome: Using NGS Technology to Investigate a Prairie Plant Endophyte Community

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Abstract

Microbial ecology is a growing research interest within the field of ecology due to increasing awareness of valuable microbial effects on plant and ecosystem health. Pathogenic microbes cause many serious plant diseases and can greatly damage plant tissues, leading to decreased growth abilities. Beneficial microbes, however, can confer strong plant growth promoting effects to plants; fungal and bacterial microbes in the rhizosphere provide plants with essential nutrients, and endophytes within plant tissues modulate plant growth and stress hormones. These microbe/plant relationships have been harnessed to benefit plant growth in agriculture and ecological restoration. Recent developments in metagenomic technology have made it cost-efficient and feasible for non-microbiologists to survey the microbial community in an ecosystem of interest. Using Next Generation Sequencing (NGS) techniques, we examined the bacterial endophyte community within imperiled Puget Prairie ecosystems. We sampled 17 plant species across 56 plots, for a total of 335 stem samples. Samples were surface sterilized and rRNA from bacterial endophytes was extracted, then the V4 region of the 16s rRNA gene was sequenced. Raw reads were processed through a bioinformatics pipeline and assigned to operational taxonomic units (OTU's). PERMANOVA and Pairwise Tests were used to evaluate differences in endophytic community composition between plant samples and sampling locations. PCoA was performed to confirm differences indicated in the PERMANOVA tests.

Effects of Different Functional Types and Extreme Rainfall Events on the Carbon Flux and Biomass in a Northern Great Plains Mixed Grassland

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Abstract

Larger but fewer extreme rainfall events are predicted to become more common in the Northern Great Plains. Both rainfall event size and frequency, and vegetation functional group strongly influence net ecosystem exchange (NEE) and aboveground biomass. We compared NEE and vegetation growth in a two-factor split plot design experiment with two patterns of rainfall events (ambient and low frequency but larger size rainfall events with the total amount held constant) and two functional types (C3- and C4-dominated pastures) with five replications at the Cottonwood Field Station near Philip, SD. We hypothesized that extreme rainfall events would (1) alter the balance between C source and sink processes in both pastures; and (2) benefit the growth of grasses in the C4 pasture but not C3 pasture as suggested by the "Bucket Model". Results following one year of the experiment showed that (1) extreme rainfall enhanced C release from the C4 pasture all summer. However, in the C3 pasture, extreme rainfall caused C loss in the early summer, but increased C uptake later in the summer. (2) Biomass was higher throughout the summer in the ambient rainfall treatment of the C4 pasture but extreme rainfall increased biomass in the C3 pasture during later summer. We conclude that (1) the extreme rainfall would enhance the C release in the C4 pasture and alter the timing of net C uptake and release in the C3 pasture by enhancing uptake during mid to late summer. (2) While ambient rainfall may benefit the growth of plants in the C4 pasture, extreme rainfall events may benefit growth of plants in the C3 pasture. The extreme rainfall events had very different effects on the carbon flux and biomass in the mixed grassland with different functional types.

Soil Responses to Eastern Red Cedar Encroachment and Prescribed Fire in South-Central South Dakota

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Abstract

Eastern red cedar (ERC) encroachment is converting grasslands into woodlands in the Great Plains. ERC afforestation facilitates the transformation of grassland vegetation into forest litter generally comprised of ERC needles and other organic material, which has the potential to alter soil properties of native grasslands. The objectives of this study are to evaluate soil physiochemical properties and soil microbial communities associated with ERC afforestation and vegetation succession one, two, and three years post-fire in south-central South Dakota. Using the Cornell Sprinkle Infiltrometer, water infiltration and sediment yield were evaluated in July of 2019 and 2020 at six randomly selected locations within each of the following five treatments: 2019 burn; 2018 burn; 2017 burn; grassland control; ERC forest control. Multiple cores of mineral soil (2-cm dia. X 15cm depth) were extracted near the same locations within the same treatment sites and analyzed for phospholipid fatty acid (PLFA) and soil chemical properties. Results from 2019 data showed reductions in microbial biomass and several key soil chemical properties under ERC forest control compared to grassland control, including SOM, P, and K. Microbial biomass, SOM, and P increased under burn treatments and trended successively toward grassland control with each year post-fire. Infiltration data will be analyzed. Our results support existing evidence that ERC afforestation can alter soil biological activity and soil chemical properties. Further, prescribed fire may be an effective tool at reversing impacts of ERC afforestation on key soil properties of native grasslands.

The Role of Land Management on Soil Microbial Communities for Climate Change Mitigation

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Abstract

Elevated CO_2 in the atmosphere has caused global temperatures to rise and ecosystem dynamics to shift in a detrimental manner. Sequestering carbon (C) in soils may present a beneficial method for reducing atmospheric CO_2, a process that is directly influenced by soil microbial activity and respiration. Compost amendments have the potential to shift microbial community composition and to increase soil C sequestration potential via both direct and indirect effects on nutrient availability and plant productivity. Rangeland ecosystems present a valuable opportunity for implementing climate mitigation practices as nearly one-third of global terrestrial C is stored in the vegetation and soils of rangelands, and with proper management have the potential to store increased amounts of C. To further investigate the relationship between soil nutrient availability and rangeland soil C storage, three rangeland sites located in Gunnison, Colorado were manipulated with compost additions in June 2019. Each site included five replicate plots per treatment (control and compost addition) with each treatment plot receiving 30.6 yds^3 of GunnyGold compost, a class A biosolid rich in C and nitrogen (N). Soil samples were collected in August 2020 for the analysis of soil organic C content, total N, microbial biomass C and N and microbial identification via PLFA analysis. Soil respiration, as measured by CO_2 efflux, has been measured weekly beginning in July 2020. These values will be used to calculate the mean residence time (MRT) of C in the soil, where a longer MRT is indicative of increased soil C sequestration. Should compost additions support a longer MRT of soil organic C, these results can help to inform land management decisions regarding the utilization of rangelands to mitigate climate change.

A Review and Synthesis of Carbon Dynamics in the Sagebrush Steppe

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Abstract

A threat-based management model was created and used in the Northern Great Basin to classify and quantify sage-grouse habitat. This threat-based model created ecological states based-off of dominant plant functional groups in the sagebrush steppe, with transitional paths between each state. Six ecological states were defined: 1) sagebrush and perennial grass co-dominant, 2) perennial grass dominant, 3) annual grass invaded, 4) degraded sagebrush, 5) sagebrush with initial juniper encroachment, and 6) advanced juniper encroachment. These six ecological states provides a good classification framework to evaluate carbon dynamics across temporal and spatial scales. Using these six ecological states we conducted an intensive literature review of peer-reviewed primary literature, federal publications, and extension publications to determine the current knowledge about carbon dynamics in the sagebrush steppe. We found that aboveground carbon pools are characterized well among our different ecological states. However, belowground carbon pools are poorly characterized even though more carbon is stored belowground than aboveground in the majority of these ecological states. Finally, carbon fluxes in the sagebrush and perennial grass dominated state, as well as both juniper encroached states are being characterized somewhat, but in the annual grass invaded and perennial grass dominated states more research needs to be done.

Mixing Plant Litter with Soil Enhances Its Decomposition in Semiarid Grassland Ecosystem

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Abstract

Plant litter decomposition is critical to improvement and sustainability of grassland soil fertility and its productivity. Litter decomposition is controlled by abiotic factors such as soil moisture and temperature, as well as the location of litter and litter quality. Plant litter in these systems can be present on soil surface, and/or mixed with soil by cattle trampling, especially under intensive grazing management scenarios. To evaluate the effect of abiotic factors on decomposition, we conducted a 13-week laboratory incubation experiment to quantify the effects of different soil moisture (23, 37, and 50 % water filled pore space) and temperatures (10, 20, and 30 ◦C), and the placement of litter (litter on top of or mixed with soil) on decomposition of organic carbon. For the litter on top treatment, the average litter carbon (C) decomposition across all soil moisture accounted for -1.8%, 8.1 and -1.7% of the total C at 10, 20 and 30◦C, respectively. For the soil-litter mixed treatment, the litter C decomposition accounted -2.8%, 19.9%, and 15.2% for temperatures of 10, 20 and 30◦C, respectively. Compared to litter on top and no litter treatments, soil-litter mixing resulted in a significantly higher amount of C loss at 30◦C (6.34 ± 1.0 %). This suggests that soil-litter mixing facilitated by cattle trampling may increase litter decomposition. As such, we expect more intensive grazing to accelerate litter C losses and decrease litter soil C storage.

Cattle Stocking Rates Have Greater Impact on Soil Carbon Than Climate in Mixed Grassland of Saskatchewan, Canada

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Abstract

Past studies show variable results on whether grazing has a positive or negative effect on grassland soil carbon (C). This inconsistency is partly attributed to the limited spatial extent of datasets linking grazing to soil C, along with the lack of specific data on livestock stocking. We examined the relationship between soil organic and inorganic C stock, and long-term cattle stocking (7-27 years) on 32 pastures distributed across 9 regional grazing allotments across an expansive agro-climatic gradient in the Mixedgrass of Saskatchewan, Canada. Cattle stocking rates were compiled from detailed records of the number and class of animals in each pasture, including entry and exit dates. To compare the relative effect of livestock stocking and climate on soil C, we used an information theoretic approach to compare explanatory models. Results showed that total soil organic C stock, and more specifically C within the upper 15 cm of mineral soil, was more closely associated with historical cattle stocking rates than climate (mean annual precipitation). To further examine the mechanisms accounting for this increase we evaluated vegetation composition data from these grasslands. Notably, range condition scores declined with increasing soil organic C stock, largely due to a shift from primarily native grassland vegetation to communities that included a substantial non-native component. Across all vegetation, increases in soil organic C were most closely associated with increases in *Poa pratensis*, which in turn, coincided with increased cattle stocking. Finally, across the 60 cm maximum sampling depth, soil inorganic C comprised an average of 35% of total C stock, but ranged from 19 to 47% among all paddocks, and was unaffected by cattle stocking rate. These results provide unique insight into both how and why cattle stocking may impact soil organic C in mixed prairie subject to cattle grazing.

Carbon Stocks and Nutrient Availability Under Shrub, Grass-Forb, and Tussock Vegetation in a New Zealand High-Country Rangeland

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Abstract

Even small improvements to soil carbon (C) have the potential to play an important role in mitigating anthropogenic climate change. A particular concern in New Zealand is how to best protect and develop soil resources in steep rangelands above 400 m altitude, to benefit both farm production systems and the environment. This research aims to assess how differences in dominant vegetation and land use affect topsoil C stocks and associated soil nutrients in a high-country rangeland catchment at Mt. Grand Station, a Merino sheep and beef cattle station on New Zealand's South Island.

At mid-lower altitudes (450 – 850 m), areas of kānuka (*Kunzea ericoides*, a pioneering native woody shrub) and naturalized grass/legume associations were located within close proximity of one another (<2 km.) using ArcGIS. Sites of comparable slope, aspect and elevation were then selected for seasonal (winter and summer) soil sampling, enabling comparisons of soil C, macronutrients and trace elements. A separate sampling experiment was conducted at higher altitudes (1000 – 1400 m), where native tussocks are dominant; three species were similarly selected. Soil was sampled from the base of prominent snow tussocks and from adjacent inter-tussock spaces.

Preliminary results show increased topsoil C storage under kānuka than in naturalized grassland communities, which was more pronounced in the summer (up to 32.84 %). Concentrations of total phosphorus (TP) and total nitrogen (TN) were highly variable across sites, possibly reflecting differences in grazing pressure and aerial fertilizer application. Topsoil C storage was consistently significantly higher from tussock bases in comparison with inter-tussock spaces (up to 46.63 %), with a similar trend for TP (up to 41.31 %) and TN (up to 21.62 %). These findings show the potential for increasing soil C sequestration with reversion to native shrub, and the restoration of tussock grassland in New Zealand's rangeland environments.

Soil Microbes Support the Use of Patch-Burn Grazing on Semi-Arid Grasslands in the Northern Great Plains

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Abstract

The continued conversion of grasslands to other land uses throughout the North American Great Plains increases the need to maintain and improve ecosystem service delivery from remaining grasslands to meet production and conservation goals. In this study, we investigated how the combination of patch-burning and livestock grazing affected soil nutrients, decomposition activity, and microbial abundance and composition on semi-arid post-Conservation Reserve Program grasslands in southwestern North Dakota. We collected soil samples during the 2018, 2019, and 2020 grazing seasons in three patch-burn pastures grazed by cow-calf pairs and three patch-burn pastures grazed by sheep. One-quarter of each 160-ac pasture was burned in each dormant season. We distributed sample points amongst dominant ecological sites in each patch to determine (1) how responses varied along the time since fire gradient and (2) which ecological sites were most responsive to patch-burn grazing. In each year, we measured ammonium, nitrate, calcium, magnesium, phosphorus, potassium, total carbon, and total nitrogen. In 2019 and 2020, we measured soil moisture, decomposition activity, and microbial abundance and community composition. We used mixed-effect regression models and Tukey post-hoc tests to compare nutrient responses across patches and ecological sites. We used ordination and post-hoc factor and vector fitting to compare community composition with nutrient responses and time since fire. No measured soil nutrients were lower in recently burned patches compared to other patches. Soil moisture was higher in recently burned patches than patches with the highest time since fire. Bacterial groups comprised the largest proportion of the microbial community across years, ecological sites, and time since fire. Calcium, total carbon, nitrate, total carbon/nitrogen ratio, and time since fire significantly influenced microbial community composition. That we did not find negative responses to patch-burn grazing is promising for the continued use of these disturbances on low diversity grasslands.

Soil Biogeochemistry and Grass-Forb Associations in the New Zealand High Country

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Abstract

Livestock productivity and health in New Zealand's high country is markedly improved by increasing the establishment, productivity and persistence of nitrogen-fixing plants that, in turn, are substantially constrained by soil acidity and supply of key nutrients. High country landscapes that account for the largest proportion of the country's grasslands have also been severely impacted by the dual threats of exotic and invasive mammals and weeds. Agricultural management through nutrient top-dressing and over sowing of pasture grasses and legumes favours more productive exotic pasture plants but tends to further exclude native biota. This research project aims to understand how and why native and exotic plants co-exist in the context of soil biogeochemistry.

Ryegrass (*Lolium perenne*), cocksfoot (*Dactylis glomerata*) and native silver tussock (*Poa cita*) are all companion plants of introduced clovers and other species of nitrogen-fixing plants. Nitrogen-fixing species provide obvious benefits to the grasses but we question whether grass species provide reciprocal benefits to neighboring legumes in terms of mineral nutrient acquisition.

We found that N-fixing *Lotus* had elevated concentrations of P, K and S when growing with at least one of the three grasses. Mass balance calculations showed higher contents of Mn, Zn and Mo in clover when growing with cocksfoot. Phosphorus, Fe, B and S were enhanced with *Poa cita*; clover foliage contained up to 38% higher concentrations of P and 35% higher concentrations of Fe when growing with tussock grass. Organic acid and phytosiderophore root exudates are likely to play a key role in explaining these findings.

There appear to be mutual advantages for nutrient acquisition when legumes and grass grow together. Understanding the subtleties of soil biogeochemistry has application both in relation to the constraints of nutrients in high country soils for productive pasture and to the importance of conserving native tussock grassland vegetation.

Wildlife Habitat & Management

The Effect of Brush Canopy Coverage on Trap Site Success for Northern Bobwhites

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Abstract

Researchers trap northern bobwhites for a variety of purposes (e.g., mark-recapture, population parameters, and translocations). Typically, the size and accessibility of a study area dictate trap placement and overall trapping effort. However, local landscape characteristics (e.g., brush canopy cover) can influence the distribution and abundance of bobwhites, which may influence individual trap site success. The objective of this study is to determine the effect of brush canopy coverage on trap site success. The study is taking place on East Foundation's, San Antonio Viejo Ranch. Trap sites are randomly selected along main access roads within the designated study area. We obtained percent of brush canopy coverage for the hectare surrounding each trap site using classified imagery from the 2016 National Agriculture Imagery Program. In total, we baited and trapped at 100 individual sites in 2018–2019 (December 2018 to April 2019) and at 125 individual sites in 2019–2020 (October 2019 & January 2020). The mean brush canopy coverage of all trap sites was 23% and ranged from 1% to 75%. The probability of trap site success decreased with increasing brush canopy coverage during the 2018–2019 trapping season, but there was no significant influence in 2019–2020. We assume that annual differences in trap site success are influenced by a variety of factors; such as bobwhite density fluctuations, intervals between baiting, annual timing of trapping, and overall acclimation to bait on a historically un-baited ranch. In conclusion, researchers may increase the efficiency of trapping northern bobwhites in early spring and during years with relatively low densities by selecting trap sites in areas with <20% brush canopy coverage.

Bobwhite Response to Cattle Grazing in South Texas

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Abstract

Range management practices to improve habitat for wildlife by reducing brush and increasing herbaceous plants, coupled with reduced stocking rates, can lead to dense stands of dominant grasses, such as four-flower trichloris (*Trichloris pluriflora)*. This monoculture of four-flower trichloris creates dense unsuitable vegetation for bobwhite quail (*Colinus virginianus*), reduces plant species diversity, and alters ecosystem functions. The objectives of this study are (1) to evaluate the effects of a proper cattle grazing regime to improve bobwhite habitat and (2) develop a management guide documenting how to use cattle grazing can be used as a tool to reduce the density and cover of dominant grasses allowing other plants to grow. The study area is two pastures, totaling about 2,500 hectares, in Duval County, Texas. One pasture will serve as the control while the other will be grazed to maintain a stubble height of 30 to 40 centimeters. We placed 10 grazing exclosures as well as 10 (25 meter) transects within each treatment to determine botanical composition and cover. Double sampling is conducted monthly to determine forage standing crop, percent cover is also recorded along each transect at each meter. Forage standing crop, plant species richness, total plant cover, and forage utilization will be calculated. Additionally, bobwhite quail will be trapped and fitted with radio transmitters to track their movement and determine nest site selection, breeding season survival, and nesting success. This study will shed light on how bobwhites respond to proper cattle grazing which in turn may be used for managing their habitat across South Texas.

Bison Diet in Badlands National Park, South Dakota

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Abstract

Badlands National Park contains one of the largest protected expanses of prairie in the United States, which supports a herd of nearly wild bison. The park nevertheless is too small to accommodate bison's natural nomadic behavior, which in the past resulted in their ephemeral but intense influence on Great Plains grasslands. Consequently, active management of the number of bison in the park is necessary to conserve the plant species and communities on which the bison and other wildlife depend. Quantitative understanding of bison use of available forage will help park managers refine bison population size targets. To contribute to this understanding, we used metabarcoding of chloroplast DNA to assess the relative abundance of protein from key plant groups and individual species in bison fecal material collected from across the Badlands bison range from May 2016 to August 2018. We composited fecal material collections into temporally cohesive samples before analysis in order to investigate temporal dynamics and variation in bison diet. When averaged over all 87 samples, cool-season grasses—the dominant plant type on the landscape—constituted 52.3% (± 2.6 SE) of protein consumed. Their contribution to diet was greater in spring and fall than in summer ($P < 0.001$). Forbs made up 36.3% (± 2.7) of protein consumed overall, with their contribution to diet being greater in summer—when they comprised 44.2% (± 3.3) of protein consumed—than fall or winter ($P < 0.001$). Invasive annual grasses contributed 2.7% (± 0.4) of protein consumed overall but had no clear seasonal pattern in bison diet. Our sampling methods preclude determining whether these proportions represent dietary preferences or avoidance. However, when combined with plant production, composition, and utilization data from areas with different levels of bison occurrence, they will provide a clearer picture of how bison are using this landscape.

Population Trends and Distributional Changes: Water Availability Influences Bi-State Greater Sage-Grouse in a Stochastic Environment

Steven Mathews[1], Peter Coates[1], Mark Ricca[1,2], Brian Prochazka[3], Shawn O'Neil[1], John Severson[1,4], Shawn Espinosa[5], Scott Gardner[6], Sherri Lisius[7], David Delehanty[8]

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Abstract

The Bi-State Distinct Population Segment (DPS) of greater sage-grouse (*Centrocercus urophasianus*; sage-grouse) occurs along the California and Nevada border, and has undergone multiple evaluations for protection under the Endangered Species Act of 1973. To help inform policy and management decisions, we carried out a comprehensive analysis of population trends and habitat selection using decades of count surveys and telemetry data within a Bayesian hierarchical modeling framework. We estimated annual finite rate of change ($\hat{\lambda}$) during periods of 11 ($\hat{\lambda}$ = 0.99), 18 ($\hat{\lambda}$ = 0.99), and 24 years ($\hat{\lambda}$ = 1.02), of which these temporal scales accounted for biases associated with environmental stochasticity that drives oscillations in abundance over time. Cumulative reduction in abundance was 9.6 and 15.7% since 2008 (11-year) and 2001 (18-year), respectively, while populations experienced increases in abundance by 57.7% since 1995 (24-year period). However, variation in trends among subpopulations were evident, such that four of the nine subpopulations exhibited 10-year extinction probabilities of over 60%. We estimated $\hat{N}$=3,305 (95% CRI 2,247–4,683) sage-grouse within the DPS during 2018. Sage-grouse also exhibited distributional contraction in the DPS as a whole, mostly associated with the periphery populations. These changes appeared to be influenced by the onset of drought during 2012. Habitat models revealed that sage-grouse broods within the historically largest subpopulation utilized mesic resources associated with irrigated pastures during the late season, and severe loss of availability of water during drought appears to have reduced habitat during this critical life stage. Although we did not evidence long-term declines in abundance within the DPS, as a whole, habitat protection in core areas and conservation actions aimed at reducing range contraction, such as translocation of individuals, will likely help facilitate long-term persistence of this unique geographically isolated population.

Free-roaming Horses Disrupt Greater Sage-Grouse Lekking Activity in the Great Basin

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Abstract

In recent decades, free-roaming horse (*Equus caballus*) populations in western North America have increased while populations of sympatric greater sage-grouse (*Centrocercus urophasianus*) have concomitantly declined substantially. Multiple studies have reported the adverse impacts of free-roaming horses on measures of environmental quality and on native wildlife, specifically ungulates. Although multiple indirect mechanisms whereby free-roaming horses could impact sage-grouse have been proposed, direct interactions between free-roaming horses and sage-grouse have not been documented to date. Using Bayesian multinomial logistic models, we investigated the response of breeding male sage-grouse to the presence of native (i.e., mule deer *Odocoileus hemionus*, pronghorn *Antilocapra americana*) and non-native (i.e., cattle *Bos taurus*, free-roaming horses) ungulates on active leks throughout the state of Nevada during 2013–2019. We found sage-grouse were five times more likely to be present on leks concurrent with native ungulates relative to non-native ungulates. Furthermore, when we evaluated sage-grouse response at the ungulate species level, sage-grouse were least likely to be present on leks when free-roaming horses were also present. Our results suggest that free-roaming horse presence negatively influences sage-grouse lekking activity. Persistent disruption of leks by free-roaming horses may reduce breeding opportunities for sage-grouse, posing a non-trivial stressor to a species that reproduces slowly and is already sensitive to disturbance. Additionally, free-roaming horse management areas overlap with approximately 55% of core and priority sage-grouse areas within Nevada, increasing opportunities for interspecific conflict. Our findings underscore the need for additional research examining responses by non-ungulate native wildlife to increasing free-roaming horse populations and find solutions that balance use of rangelands by wildlife, livestock, and free-roaming equids.

Horse Trading for Grouse: Exceeding Appropriate Management Levels Adversely Affects Sage-Grouse Populations

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Abstract

Free-roaming horse (*Equus caballus*) populations have increased precipitously in sagebrush ecosystems and, currently, well-exceed maximum appropriate management levels (max AML), which were set to balance utilization by free-roaming and domesticated grazing ungulates. Concomitantly, greater sage-grouse (*Centrocercus urophasianus*; hereafter, sage-grouse) are sagebrush obligates that have experienced population declines within these ecosystems as a result of steady and continued loss of habitat. Although research indicates that overabundant horse populations adversely impact sagebrush ecosystems, empirical evidence linking horse abundance to sage-grouse population dynamics is missing. We employed Bayesian state-space models to estimate population rate of change (λ) using 15 years of male counts on sage-grouse leks (traditional breeding grounds) as a function of horse abundance relative to max AML and other environmental covariates (e.g., wildfire, precipitation, % sagebrush cover). Additionally, a post-hoc impact-control design was employed to validate current settings of max AML values as related to sage-grouse population responses, while controlling for natural stochasticity and broad-scale oscillations of λ. On average, for every 50% increase in horse abundance over AML, our model predicted an annual decline in sage-grouse abundance by 3.5%. Horse abundance at or below AML coincided with λ estimates that were consistent with trends at non-horse areas elsewhere in the study region. Thus, maximum AML, as a whole, appeared to be set adequately in preventing adverse impacts to sage-grouse populations. Results indicated a 93% and >99% probability of sage-grouse population decline relative to controls when AML is 200% and ≥250%, respectively. If free-roaming horse populations continue to grow unabated, sage-grouse populations in horse-occupied areas will be reduced by ~60.9% within 15 years based on model projections. Monitoring frameworks that include sage-grouse would be beneficial to understand synecological effects and guide management decisions that promote co-occurrence of free-ranging horses and livestock with sensitive wildlife within landscapes subjected to multiple uses.

Evaluating the Greater Sage-Grouse Umbrella for Grassland Birds in Northeastern Wyoming

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Abstract

Steep biodiversity declines across North American rangelands have led researchers and managers to seek ways to balance the needs of multiple species of conservation concern. The umbrella species concept provides an opportunity to protect diverse wildlife under the umbrella of a single charismatic species. Prairie and shrubland grouse have been advanced as umbrellas for these ecosystems, however the actual efficacy of these umbrellas has been variable and a test of how well the umbrella functions at transitional zones between ecoregions is lacking. We evaluated the extent of overlap between the greater sage-grouse (*Centrocercus urophasianus*) umbrella and grassland songbirds in northeastern Wyoming, at the ecotone between the sagebrush steppe and the Great Plains. We leveraged existing data layers representing nesting and brood-rearing sage-grouse habitat and habitat suitability for eight grassland songbird species. We applied a permutation-based hypothesis test using neutral landscape models to determine whether overlap between our focal songbirds and greater sage-grouse was greater than expected by chance (an underlying assumption of an umbrella species). In a 90% 2-tailed test, three songbird species (western meadowlark [*Sturnella neglecta*], horned lark [*Eremophila alpestris*] , and lark bunting [*Calamospiza melanocorys*]) had greater overlap than expected by chance, and loggerhead shrike [*Lanius ludovicianus*] displayed marginal overlap, while western kingbirds [*Tyrannus verticalis*] showed a marginally negative relationship. No relationship was observed between sage grouse and grasshopper sparrows (*Ammodramus savannarum*), vesper sparrows (*Pooecetes gramineus*), or lark sparrows (*Chondestes grammacus*). Three of the four positively associated species either nest within sagebrush (loggerhead shrike) or often select nest locations underneath sagebrush (western meadowlark, lark bunting), highlighting nesting substrate as an important niche axis to consider when evaluating the umbrella species concept. This research helps improve our understanding of the functionality of the sage-grouse umbrella for grassland songbirds at the eastern edge of the sagebrush steppe.

Temperature and Fire Management Interact to Influence the Thermal Landscape for a Terrestrial Turtle

Ellen Robertson[1], Evan Tanner[2], Dwayne Elmore[1], Samuel Fuhlendorf[1], Jennifer Knutson[1], Jonathan Mays[3], John Weir[1], Scott Loss[1]

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Abstract

As global temperatures warm and the frequency of extreme weather increases, there is a growing need for understanding the thermal properties of landscapes in relation to wildlife use. Animals can move among vegetation patches, and a mixture of thermally diverse patches provides options for thermoregulation as climatic conditions change. A key aspect of the thermal properties of landscapes is vegetation structure. Habitat management, such as prescribed fire, can alter vegetation structure and consequently the thermal landscape and may have underappreciated effects on animal habitat selection in relation to climate. Here, we assess influences of temperature and fire management on habitat selection of a terrestrial turtle (three-toed box turtle [*Terrapene carolina triunguis*]) in the southern Great Plains of the United States by linking data on time-since-fire from 18 experimental burn plots with 5-minute interval temperature data and vegetation heights mapped at 1 meter resolution. We found that turtles select time-since-fire gradients differently depending on temperature and land-cover type. When temperatures are moderate (~24 - 29 °C), turtles use recent time-since-fire locations, but with cooler or hotter temperatures, they seek taller vegetation heights, including later time-since-fire locations and more forested land-cover types that provide shade and thermal insulation. Our results highlight that fire management influences the thermal landscape and wildlife habitat selection and can be an actionable way to improve habitat for wildlife under global change.

Assessing the Impacts of Mid-Contract Management on Lesser Prairie-Chicken Use of Conservation Reserve Program Lands

Evan Tanner[1], Ashley Tanner[1], Samuel Fuhlendorf[2], Dwayne Elmore[2], Craig Davis[2], John Polo[3]

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Abstract

The lesser prairie-chicken (*Tympanuchus pallidicinctus*; hereafter "LPC") is a declining species of North American prairie grouse that has benefited in recent decades from the enrollment of the Conservation Reserve Program (CRP) in the Southern Great Plains. Despite the potential of CRP to influence LPC conservation, empirical evidence of how individuals and populations function in relation to spatially explicit CRP cover is lacking. Moreover, temporally explicit events such as mid-contract management associated with CRP contracts may have impacts on the use of these lands by the LPC. In this study, we sought to determine how mid-contract management (i.e., prescribed-grazing) of CRP influenced movement patterns of LPCs. From April to January 2014-2015, we captured and fitted GPS transmitters to LPCs on a lek located within CRP in Beaver County, Oklahoma. Prescribed grazing (30 cow/calf pairs on 122 ha) associated with mid-contract management was implemented on 2 July 2014 and lasted 84 days. We found similar relationships across treatment (experiencing prescribed grazing) and control groups with regards to the interaction between the proportion of the step length in CRP and whether or not the step length ended in CRP. Step lengths did not differ across grazing periods (pre-, during, or post-) when a movement ended in CRP for the treatment group where-as there were differences for the control group. Our results suggest that the mid-contract management associated with individuals in our study did not influence LPC movement patterns during this practice. This potentially highlights that managers and conservation scientists should think about habitat quantity rather than quality or composition in human influenced matrices within the LPC distribution. However, our sample size is limited and future research should explore how the timing and variation in specific mid-contract management practices may change these relationships.

Grazing by Grizzlies: Forage Selection and Associated Endocrine Profiles in an Omnivore.

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Abstract

Meat, fruit, seeds, and other high energy foods are often highly localized and understanding which factors influence consumption of these food is a common foci of bear management and conservation. However, the most frequently consumed bear foods, graminoids and forbs, are much more widespread but of lower energy density and our understanding of factors that influence grazing by bears, or its physiological consequences, is considerably less. Here, we described bear diets with a novel approach, measuring the concentration of chlorophyll in bear scats (fecal chlorophyll) to index the proportion of the recent diet that was composed of photosynthetic leaves and stems from graminoids and forbs. To describe endocrine associations with diet, we also measured fecal glucocorticoids and fecal chlorophyll in 351 black bear and grizzly bear scats from Yellowstone National Park in 2008 - 2009. We compared models of fecal cortisol and fecal chlorophyll concentrations considering the effects of spatial, dietary, scatological, and bear-specific factors. Fecal cortisol levels were best explained by models that included a positive effect of fecal chlorophyll, which was also the strongest predictor of fecal cortisol. Effects of scat composition, scat weathering, bear age, bear sex, species and other factors that have previously been shown to influence fecal cortisol in bears were not important unless fecal chlorophyll was excluded from models. Fecal chlorophyll was best explained by spatial models. The top models of fecal chlorophyll suggested grazing was higher closer to trails, likely reflecting the non-random distribution of trails alongside streams and lakes, where forage production may be highest. Fecal chlorophyll shows promise for measuring the 'greenness' of diet in herbivores, but in omnivores this new index likely reflects the proportion of the diet composed of herbaceous plant material and the lack of recent consumption of alternative high-energy foods.

The Importance of Fire Severity for Bighorn Sheep Habitat Restoration

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Abstract

There has been an increasing push to restore bighorn sheep to their historical range through translocation and habitat restoration. Restoration efforts often utilize low intensity prescribed fire to enhance bighorn sheep habitat; however, research has shown mixed responses of sheep to prescribed fire across different regions. This is likely tied in part to the fact that fire is often treated as a binary entity on the landscape (i.e. fire versus no fire). Little is known about the complexities of time since fire and fire severity in shaping bighorn sheep habitat use. We conducted multi-scale assessment of male and female Rocky Mountain bighorn sheep (*Ovis canadensis canadensis) habitat selection* over an 8-year period. We aimed to identify the spatial scales at which bighorn sheep responded to habitat features and determine how time since fire and fire severity can shape bighorn sheep habitat selection between sexes and across seasons. Large spatial scales were generally better at predicting bighorn sheep habitat selection. While associations with escape terrain, elevation, and perennial and annual forb and grass cover varied by sex and season, bighorn sheep were consistently positively associated with low and high severity fire. However, females increased use of low and high severity burned areas with greater time since fire, suggesting studies conducted 1-2 years post-fire are unlikely to capture the full outcomes of fire for female sheep. Male sheep tended to decrease use of areas that burned at high severity with greater time since fire. Our results support the importance of considering fire driven landscape heterogeneity associated with fire severity and time since fire for Rocky Mountain bighorn sheep habitat restoration.

Human Policy Influences Roosting Ecology of an Imperiled Prairie Grouse

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Abstract

All animals must select sites to rest and may spend a large portion of their lives doing so. Yet until recently, logistical constraints often prohibited researchers from understanding roosting ecology for many species. With the advent of technology such as GPS transmitters, opportunities to obtain information on roosting sites were made easier, though roosting ecology is still largely understudied for many organisms. We sought to identify how landcover, anthropogenic features, and human policy (i.e., presence of the Conservation Reserve Program [CRP]) influenced roost site selection and movement patterns of the lesser prairie-chicken (*Tympanuchus pallidicinctus*; hereafter "LPC"), a declining species of North American prairie grouse. From March to May 2013-2016, we captured and fitted GPS transmitters to LPCs within Beaver County, Oklahoma and set transmitters to obtain two nocturnal locations per 24-hour period, annually. We used discrete choice models and generalized linear mixed effects models to determine what influenced roost site selection and movements to roosting sites, respectively. Roost sites were closer to CRP, leks, and croplands than would be expected at random. Conversely, roost sites were located further away from shortgrass prairie, roads, and transmission lines than random locations. Based on standardized beta coefficients, the distance to the associated lek (β = -7.20, SE = 0.77) and CRP (β = -4.21, SE = 0.54) were the two most influential variables on determining roost sites. Similarly, individuals traveled shorter distances to get to roost sites when the step length contained a greater percentage of CRP. However, movements to the roost were greater when a roost site was in CRP as opposed to outside CRP, suggesting individuals will travel longer distance to roost in CRP if they were located outside of CRP before sunset. Our results indicate that human policy is critical in influencing roosting ecology of LPCs within this region.

Analysis of Survey Methodologies for Wintering Rio Grande Wild Turkey in Cross Timbers and Post Oak Savannah Ecoregions.

Chloe Bates[1], Humberto Perotto-Baldivieso[1], William Kuvlesky[1], Alfonso Ortega Santos[1], Leonard Brennan[1], Jason Lombardi[1], Michael Page[1], Nicholas Kolbe[2]

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Abstract

Wild turkey *(Meleagris gallopavo)* are an economically and culturally important species in Texas. While numbers across the geographic distribution range have increased, numbers in Texas have been in decline. Furthermore, there is a lack of reliable methods to estimate turkey density in different ecoregions. Therefore, the aim of this study is to assess the precision of survey methodologies for estimating wild turkey abundance. The specific objective of this study is to determine the precision of survey methods in estimating Rio Grande wild turkey density on two ecoregions: Cross Timbers, and Post Oak Savannah. Our study sites are on the Camp Swift Army Base in Bastrop, TX and the Camp Bowie training center in Brownwood, TX. We will conduct the following surveys: road, roost, and camera. These surveys will take place January-March of 2021 and 2022; we will survey each site for a week until the end of March. Road survey routes will be selected randomly and will be proportional to each habitat type on each site. Our goal is to complete at least 100 16-kilometer survey routes per installation per survey season. Road and roost surveys will be conducted based on the consensus of existing literature. Camera-traps will be placed at each site with four camera stations (two cameras) per average Rio Grande wild turkey home range (12 km^2). Turkey trapping will occur on each site in December 2020; each turkey captured will be marked with unique identity tags. We hypothesize that road-based surveys and camera-traps will provide significant information to estimate density across the landscape. This research will aid wildlife managers and biologists in conserving and managing Rio Grande wild turkey. Specifically, this research will: help landowners determine the density and locations of Rio Grande wild turkey on their property, to better manage their land and wildlife.

Diet Composition of Vicuñas (Vicugna vicugna) Using Stool Microhistology Technique

Katherine Capuñay, Samuel Pizarro, Javier Naupari

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Abstract

Peru has the largest population of vicunas (Vicugna vicugna) grazing high Andean grasslands. Knowing the composition of the vicuña's diet will allow us to develop strategies for the conservation of plant diversity and ensure their ecological and economic sustainability in the medium term. The composition of the vicuña's diet was evaluated using the fecal microhistology technique in feces collected in four well-defined types of vegetation during November (summer) in the San Cristóbal-Lucanas Rural Community, Ayacucho, Peru. Fourteen plant families and 35 species were identified in the excreta of tussock grassland (TuG), short-grasses (SG), mixture of tussock grassland and short-grass (TuSG) and, tolar (shrub) and short-grasses (ToSG). The Poaceae family was the most frequent and the main species were *Nassella* sp. and *Calamagrostis vicunarum*. Grasses were the most consumed functional group (63% -74%) in all vegetation types. Likewise, in SG and Tu-SG, herbaceous and shrubs occupied the second and third place in the diet respectively; on the other hand, in TuG and ToSG the consumption of herbaceous plants was similar to shrubs, suggesting the consumption of these functional groups as complementary in their diet. The consumption of graminoids was similar in all vegetation types and below 6% of the diet. *Festuca rigescens* was the only grass highly selected in all places, while the preference of the others grasses varied. The preference of herbaceous plants was quite variable within the four types of vegetation. The graminoid species *Distichia muscoides* and *Eleocharis albibracteata* were highly selected and it was associated with movements towards water sources. The shrubby Ephedra americana, *Tetraglochin cristatum*, *Senecio* sp. and *Parastrephia quadrangularis* were highly preferred. In the dry season, the vicuña selects less palatable shrubs as a food response due to the low plant diversity and plants' phenological decline.

Simulation Model of Vicuñas Population Dynamics in Changing Environmental and Management Scenarios

Samuel Pizarro, Javier Ñaupari

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Abstract

The vicuña as a protected species for more than 40 years in Peru in high Andean rangelands ecosystems, whose conservation interest arises as a response to extinction, with a population of 200,000 individuals registered in 2012 managed by rural communities. The commitments assumed to move from conservation to the use of vicuña require changes in the conception of utilization, based on the ecological, social and economic balance, so beyond the technical management of this specie, it is necessary to expand the state of knowledge in the aspects of conservation and use of integral biodiversity, considering that currently science and technology make it possible to retake these concepts from a systemic and detailed view. This study aims to develop a model based on agents to describe the population dynamics of the vicuña, and contribute to the design of a multifactor sustainable management model for this species, taking as starting points the available information regarding socioeconomic factors involved, population of vicuñas censuses, complemented with the history of annual vicuñas management, historical climate information and vegetation submodels based on remote sensing, considering the random effects of each variable on population dynamics and driving. The present investigation is carried out in the Campesino Community of San Cristóbal, Lucanas, Ayacucho, where two modeling scales are defined, the first at the level of policies in the management of vicuñas, which it considers as preliminary agents of modeling to the forest service (SERFOR), Barbara D'Achile Pampa Galeras National Reserve, Local Government, Communities, Poachers and Demand Fiber Market; and the second with the vicuña as an individual and intrinsic processes such as metabolism, social, reproductive behavior and interaction with their habitat that considers the physical environment and its attributes (food, water, coverage), competitors and predators, considering wildlife and domestic.

A Web-Based Tool to Assess Sage Grouse Habitat

Eric Sant, Gregg Simonds

Open Range Consulting, Park City Utah, USA

Abstract

The Greater Sage-Grouse record of Decision and Approved Resource Management Plan Amendment includes habitat objectives for sage grouse. These objectives are known collectively as Table 2.2. This presentation is a demonstration of how high-resolution vegetation data and web-based tools can be used to assess and quantify a land unit for sage grouse habitat. The tool includes mapping, graphing, and table options as well as the integration of AIM plots.

Tools & Technologies

The following summaries describe tools and approaches the Society for Range Management has not fully evaluated and does not recommend or endorse their use. However, they are presented here because readers may find them valuable and effective in their specific situation.

Open Range Consulting: Featuring the Tools of Earth Sense Technology

Anne Blackwood

Open Range Consulting, Park City, USA

Abstract

Healthy rangelands can change the world with their vast benefits, including crucial wildlife habitat, biodiversity, provide watersheds, carbon sequestration, grazing and forage, renewable and mineral resources, and recreational activities. Range management is challenging because of the lack of tools to appropriately and accurately map the landscape. Managers need spatially rich information to make informed decisions, to make necessary adjustments, and to monitor successes or shortfalls over time. Without these tools it is difficult to measure progress. Open Range Consulting (ORC) has innovated tools and products that are at a scale and accuracy that can reliably be used by resource managers to improve and protect natural resources and landscapes. ORC's Earth Sense Technology Tools broaden the rangeland perspective from small expensive samples to robust landscape assessments that offer valid and useful tools which can be used to effect real change and improvements.

ORC Earth Sense products include continuous cover maps, riparian assessments, RDM maps, piosphere and carrying capacity, weed mapping and GIS in a box (table 2.2). Our products are designed to answer basic questions, while providing accurate data, so decisions can be made and adjustments in rangeland practices can be implemented and measured. Our goal is to provide tools to answer questions that can then be put into practice to aid in the protection and improvement of this worlds precious rangelands. Having both qualitive and quantitative validation suggests our products can be especially useful to managers. This poster is an example of products and tools we have created to help range mangers meet their goals and objectives and hopefully improve vital rangelands.

A Survey of Decision Support Tools for the Beef Cattle Industry

Coury Dorn, Emile Elias, Skye Aney

USDA Southwest Climate Hub, Jornada Experimental Range, Las Cruces, USA

Abstract

A survey of literature and online resources was conducted to describe the availability and usage of decision support tools (DSTs) in the beef cattle industry. This research identified >250 DSTs, including mobile applications, downloadable spreadsheets, websites, software programs, and handbooks. Each tool was cataloged and assigned to one of five categories; Production and Economics, Animal and Feed Performance, Land Management, Emissions Mitigation, and Weather and Climate. Production and Economics tools focus on operation efficiency and the financial analysis of production system components. Animal and Feed Performance tools focus on animal health monitoring and feed nutrient analysis. Land Management tools focus on sustainable land management practices. Emissions Mitigation tools focus on strategies to reduce greenhouse gas emissions. Weather and Climate tools focus on short term and seasonal weather forecasts as well as historical weather reporting. The literature revealed two crucial challenges in DST development and usage. First, DST validation is lacking in the literature. Of the >250 tools cataloged, less than 40 have been tested and validated in peer reviewed literature. The second challenge is the underutilization of DSTs in agricultural industries. Despite ongoing efforts to develop powerful agricultural DSTs, studies show that these tools remain underutilized due to factors such as the cost of service, marginal effectiveness, and prioritization of issues not addressed by the tool. The next goal of this project is to publish an online searchable tool catalog in order to provide beef cattle producers easy access to a wide range of DSTs. The catalog will contain the following tool information; name, type, developers name and region, validation or user evaluation criteria, intended audience, cost, a brief description, and links to the tool source and other relevant resources. The catalog will be hosted on the Southwestern Beef Knowledge System page of the Sustainable Southwest Beef Project (swbeef.org).

US National Vegetation Classification (USNVC) Helps Partners Collaborate on Landscape Management

Linda Ann Spencer, Carol Spurrier

US Forest Service, Washington, DC, USA

Abstract

Vegetation classification is important for conservation, scientific research and resource management. These pursuits require defined ecological units with known distributions. A standard classification helps us to manage landscapes across ownerships, and to talk about actions and outcomes. The Forest Service chairs the FGDC Vegetation Subcommittee and has a key role in implementing the US National Vegetation Classification (USNVC v2.0, www.usnvc.org). The USNVC is required of all federal agencies. It has an eight-level hierarchy and is supported by plot data. In the past two years, the Forest Service engaged with partners to improve the USNVC concepts and documentation, and tested approaches for moving from national and regional classifications to USNVC. One approach is very simple and is illustrated. The USNVC can help us describe, inventory, monitor, and study vegetation across ownerships in the United States. The dynamic content requires input from people across the country to test and refine the classification and underlying concepts. More plot data is needed for ecological context and plant community descriptions. Everyone can assist with this stewardship and in doing so, will gain understanding of the USNVC. The first step is learning the classification so try the illustrated approach. The outcomes are improved classification and a shared understanding that lead to successful collaborations in landscape management.

Western Juniper: Spatial and Temporal Canopy Cover Analysis

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Abstract

Open Range Consulting (ORC) specializes in remote sensing across Rangelands of the western US, creating products that fulfill the management needs of private ranchers and federal or state agencies. In 2016 ORC created 1 meter resolution continuous cover layers for plant functional groups across select allotments in the Burns BLM district. This data has since been used determine vegetation community within Juniper stands identified using 1 meter 2016 NAIP imagery. Juniper phases were created by calculating juniper canopy cover at 30 meter resolution. Juniper phases were determined and partitioned according to canopy densities outlined in The USGS Western Juniper Field Guide 2007. This process was then repeated using 1 meter 1985 NHAP imagery. This provided the ability to examine juniper phase changes through time and get a sense of juniper infilling versus juniper encroachment, an aspect of juniper succession that seems to be under stated. Using these data sets in conjunction with on the ground knowledge can help determine placement of a suite of treatments or range improvement projects that may hold implications for rangelands into the future.

A Piosphere Tool: Validating Predicted Cattle Distributions

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Abstract

An economical and consistent means of predicting and visualizing cattle distributions in rangelands could help inform managers in making grazing decisions. Open Range Consulting (ORC) has developed the Piosphere tool to do just this. This landscape analysis uses abiotic GIS data associated with limitations to cattle, to quantify and predict cattle distributions. A resource selection function (RSF) was built using the same set of GIS data and global positioning system (GPS) cow collar data to serve as a means of validation for the Piosphere tool. The RSF controls for the telemetry bias associated with collar data and produced a landscape scale analysis that was used to evaluate the Piosphere tool's predicted distribution. Validation was performed in two ways. Firstly, calculating the proportion of cow collar locations captured within the predicted distribution of the Piosphere tool and secondly a comparison of pixel values for each landscape scale analysis across the whole study area. The Piosphere predicted 96% of the cattle locations and produced an r squared of 0.64 when regressed with the RSF built from the GPS cow collar locations.

Expanding the Monitoring Toolbox

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Abstract

In a world of rapidly advancing technologies, did monitoring techniques get left behind? For anyone who has done line-point-intercept in the hot summer sun and wondered if there was a better way, the future is here. A vegetation transect can provide detailed information about a specific point on the landscape but only at that point. What if you could take an accurate census of the landscape instead of just a sample? By taking a photo of a plot of we can capture all the vegetation data in a plot and because it occupies a defined geometry, we can relate it spatially to a landscape scale photo.

We use an overhead photo to inventory vegetation in a plot. We then use each inventory plot to define pixel values in landscape scale imagery. These defined pixels become training points. From these training points we use software to identify vegetation across the landscape. This allows us to not just sample a pasture but to we are able to do a vegetation census. Using this data we can answer basic question like: What is the average sagebrush density across a pasture? But we can do so much more, we point to the parts of the pasture and show where there is heavy cover and where there is light cover. We can use this technique to find species. We have gone to known medusahead (*Taeniatherum caput-medusa*) sites and used these to train our software allowing us to create a map that showed where unknown medusahead sites were.

Doing a vegetation census is now possible both in terms of time and money. Monitoring techniques have been improving but the scientific community have been slow to adopt these new techniques. It's time to expand our monitoring toolbox.