2017 SRM Annual Meeting Abstracts

Oral Technical Session:
Inventory, Monitoring, and Assessment

AFRICAN DROUGHT: PIONERING CRITICAL PREDICTIVE EARLY WARNING SYSTEM FOR DROUGHT MITIGATION AND RANGELAND MANAGEMENT. Joseph N. Matere*; Food and Agriculture Organisation of the United Nations, Nairobi, Kenya

Changing climate, growing populations, settlement and increasing land area needed for crop production leads to further rangeland degradation and pastoralists who depend on mobility for their livelihoods face greater challenges, uncertainty and risk. The above conditions lead to lack of water and pasture in traditional grazing areas and along livestock migration routes often resulting in increased resource based conflict, higher livestock mortalities, poverty and non-sustainable coping strategies that further exacerbate an already precarious eco-system. Drought, erratic rainfall and lack of pasture and water influence livestock body condition, reproductive capacity and marketability, leading to unfavorable terms of trade for the pastoralists and short and long term food insecurity and malnourishment. All sectors of society are affected and there is need to focus on impact at family and community level in order to develop effective risk management and response strategies. Attaining food security remains a major commitment of the all governments in Africa. For example the Kenya government has outlined in the Agriculture Sector Development Support Programme (ASDSP 2010-2020) as well as the Vision 2030 Economic pillar its endovor to realise zero hunger by the year 2030. The population of Kenya which stands now at over 40 million is dependent on agriculture as the main stay. However against this backdrop, there remain major challenges in attaining this noble objective. More often than not, lack of accurate prediction and analysis to address the recurrent food insecurity results into cyclic nature of same impacts season after season. A novel web-based Predictive Early Warning System decision support tool was developed by FAO in collaboration with Texas A and M University and the National Drought Management Authority (NDMA). The tool integrates near real-time forage quantity assessment, short and long-term forecasting of forage and livestock water status to allow stakeholders to examine risk and identify potential tradeoffs and responses associated with drought and changing climate.

PARAMETERIZING THE PRECISION OF LINE-POINT INTERCEPT ESTIMATES BY RESAMPLING SIMULATED SPATIAL DATA. Seth Simonds*[1], Gregg E. Simonds[2]; [1]Open Range Consulting, Salt Lake City, UT, [2]Open Range Consulting, Park City, UT

Rangelands are spatially heterogeneous and characteristically so; however, the sampling protocols used to estimate rangeland attributes assume spatial homogeneity, which is

paradoxical. This study tests the hypothesis that stratified sampling techniques that assume homogeneity across the sampled space, like line-point intercept, generate statistically meaningful estimates of rangeland cover attributes. By repeatedly generating line-point estimates over simulated data with known spatial attributes, a distribution of possible percent cover estimates is created. By analyzing this distribution, the precision of line-point intercept estimates can be parametrized in terms of a truth standardized confidence interval. The results indicate a tremendous lack of precision (i.e. wide variation) in estimates generated by line-point intercept, especially for low percent cover attributes. Therefore, homogeneity of the strata cannot be assumed and stratified sampling cannot be validly applied to estimate rangeland attributes; science, policy and debate of rangelands must rest upon alternative estimating procedures.

ANNUAL PHOTO MONITORING: A RELATIONSHIP OF DROUGHT, GRAZING AND CHEATGRASS INVASION. Garry D. Brown*, Sherel K. Goodrich; USDA Forest Service, Vernal, UT

The health of rangeland vegetation can be influenced by numerous factors including grazing, fire, drought and other disturbances. It is often a combination of disturbances over time and space that result in a gradual change to the landscape. However, in some cases, continuous annual photo monitoring can capture astounding changes that can be directly associated or related to an event of specific disturbance. From an evaluation of numerous spring and fall annual monitoring using repeat photography on the Uinta Mountains, Utah, the relationship between drought and the spread of cheatgrass has been dramatic and relatively abrupt. The photos in this study identify two periods of drought that appear to have initiated a conversion of once native perennial grasses to nearly 100 percent cover of cheatgrass in a matter of a few years. Annual monitoring using simple repeat photography, especially when it comes to capturing the outcomes of annual events, will tell a story that can sometimes change our thinking or shed light on an improved management idea. This annual monitoring can assist managers to more effectively make changes, if needed, during drought conditions to maintain the preferred perennial vegetation.

DISTRIBUTION OF NATIVE GRASSLAND HABITATS IN SOUTH DAKOTA: A NEW MODEL FOR THE NORTHERN PLAINS. Peter J. Bauman*[1], Benjamin T. Carlson[1], Tanner J. Butler[1], Michael C. Wimberlly[2], Alexander J. Smart[2], Joseph G. Blastick[3], Cody Grewing[4], Matthew W. Morlock[5]; [1]South Dakota State University Extension, Watertown, SD, [2]South Dakota State University, Brookings, SD, [3]The Nature Conservancy, Clear Lake, SD, [4]South Dakota Department of Game, Fish, and Parks, Rapid City, SD, [5]Pheasants Forever, Brookings, SD

Native grasslands and their associated wetlands are crucial to emerging natural resource issues in South Dakota. We utilized the South Dakota Farm Service Agency's Common Land Unit (CLU) data and US Department of Agriculture (USDA) National Agriculture

Imagery Program (NAIP) county mosaic aerial imagery to evaluate 22.6 million acres of land 44 eastern South Dakota counties to determine the extent of remaining native grasslands. We analyzed land in approximately one mi2 sections to identify all cropping and other land disturbances. Remaining land tracts were then categorized as potentially native grassland or woodland. Finally, we removed all known water bodies > 40 acres as defined by the South Dakota Statewide Water Bodies layer to determine the remaining undisturbed grassland/wetland complex.

Overall, 5,488,025 acres (24.2%) of eastern South Dakota were designated as potentially native land. Approximately 14.9 million acres (65.9%) were deemed to have a cropping history while approximately 1.6 million acres (6.9%) were found to have some type of land disturbance not indicated by a CLU crop code, for a total of 16.5 million acres (72.8%) of all lands with a proven disturbance history. Within the 22.6 million-acre evaluation area, 1.4 million acres (6.1%) were found to have permanent protection from future conversion. Nearly 1 million acres of the approximately 5.5 million acres of undisturbed land (17.5%) had some type of permanent conservation protection status. In total, we identified 962,734 protected native acres, representing only 4.3% of eastern South Dakota's total land base. Our results will inform future decisions regarding grazing management, endangered species, and water quality related to buffer zones, wetlands, and storage and will serve as a template for the northern Great Plains.

USE OF THE GLOBAL LAND-POTENTIAL KNOWLEDGE SYSTEM FOR PLANNING AND EVALUATION OF RANGELAND RESTORATION PROJECTS.
David W. Kimiti*[1], Jeffrey Herrick[2], Amy Ganguli[1], Jason W. Karl[2], Derek W. Bailey[3], Corinna Riginos[4]; [1]New Mexico State University, Las Cruces, NM, [2]USDA-ARS, Las Cruces, NM, [3]New Mexico State University, Las Cruses, NM, [4]U. Wyoming, Laramie, WY

Lack of monitoring and reporting of rangeland restoration outcomes often hampers efforts to improve, replicate, and upscale effective restoration practices to other affected areas. The Global Land-Potential Knowledge System (LandPKS) aims to support these efforts by providing tools for land managers to inventory their resources, match treatment and control plots for restoration projects based on biophysical similarity and potential productivity, and monitor and evaluate project outcomes. We highlight current and potential applications of the LandPKS mobile application suite, including LandInfo and LandCover. LandInfo is a site characterization tool that is currently used in over 10 countries for collecting basic soil and topographic information. When combined with local climate information provided through the system, LandInfo can be used to determine site potential and identify ecological sites. LandCover is a tool for collecting soil and vegetation cover data that is compatible with large-scale rangeland monitoring efforts in the United States (e.g., NRCS National Resources Inventory; BLM Assessment, Inventory, and Monitoring program) and facilitates monitoring of changes in plant community composition and assessment of wind and water erosion risk. Both these apps provide summary results to the user immediately assessment at plot level is completed, providing real-time information for decision making. The LandPKS system allows users

to store data automatically on the cloud, negating the need for secondary data entry. In addition, LandPKS allows dynamic visualization of, and on-demand access to user data via a web portal. The open source nature of the system means that data collected is also accessible to other land managers and the larger research community. LandPKS provides tools for monitoring and evaluating restoration project outcomes and seeks to provide a framework for collecting, storing, and sharing local knowledge and scientific data necessary for informing management and policy.

PROCESS-BASED MODELING OF UPLAND EROSION AND SALT LOAD IN THE UPPER COLORADO RIVER BASIN. Sayjro K. Nouwakpo*[1], Mark A. Weltz[2], Colleen Green[3]; [1]University of Nevada, Reno, Reno, NV, [2]USDA Agricultural Research Service, Reno, NV, [3]USDI Bureau of Land Management, Denver, CO

The Colorado River is a vital resource in the United States and Mexico but is susceptible to detrimental salinity levels with salinity-related damages estimated at $385 million per year. Over 55% of sediment and salts entering the Colorado River is of natural origin with a significant contribution from accelerated soil erosion on federal rangelands. This suggests a significant potential to reduce dissolved-solids loading to the Colorado River through land and water-management activities on rangelands. In this study, we aim to develop parameter estimation equations that are valid on saline rangeland sites for use in the Rangeland Hydrology and Erosion Model (RHEM). By combining advanced 3D reconstructions techniques with traditional soil erosion and runoff assessment on 72 in-situ rainfall simulation plots, a unique insight into sediment transport processes on sparsely-vegetated landscapes was possible leading to improved salt load predictions. Long-assumed empirical links between sediment concentration and dissolved solids (salts) were verified and provided a foundation for predicting salt load with RHEM. At the fundamental level, this research is providing a unique opportunity to accurately address topics related to hillslope connectivity, sediment delivery ratio and concentrated flow erosion.

NEAR INFRARED SPECTROSCOPY FOR THE PREDICTION OF RANGELAND SOIL CHARACTERISTICS. Douglas R. Tolleson*[1], Thomas Boutton[2], John W. Walker[3], Ryan Mushinski[2], Yong Zhou[2], Claudio Casola[2]; [1]Texas A&M University, Sonora, TX, [2]Texas A&M University, College Station, TX, [3]Texas A&M AgriLife Research, San Angelo, TX

Prescribed fire and grazing are two common rangeland management practices in the Edwards Plateau region of Texas. Rapid, reliable, and cost effective assessment of soil chemical and physical properties will facilitate their application in research and management. An experiment was conducted to determine the ability of near infrared spectroscopy (NIRS) to quantify percent sand, silt, clay, organic carbon (OC), $\delta 13$ C, total carbon (TC), $\delta 15$ N, total nitrogen (TN), and total phosphorus (TP) on savanna rangelands that were: 1) burned versus unburned, 2) moderately versus heavily grazed,

and 3) within oak, juniper, or grass vegetation. Soil samples (N = 36) were collected from the top 10cm and sieved with a 2mm screen, milled to 1mm particle size and composited (approximately 10g) from triplicate samples prior to chemical analyses. Spectra (400-2500nm) were collected via NIRS. Calibrations for each component were developed using multiple partial least squares regression and evaluated using multiple coefficient of determination (RSQ) and standard error of cross validation (SECV). RSQ was > 0.9 for all components except silt (0.73) and sand (0.76). SECV ranged from 0.01 (TP) to 4.36 (clay). A series of "leave one group out" validations were performed for all group combinations; for example, a calibration developed from 27 samples from heavily grazed, moderately grazed and burned treatment groups were used to predict 9 control group samples, etc. The simple coefficient of determination, standard error of prediction, and slope were: OC (0.92 ± 0.02; 1.07 ± 0.15; 0.90 ± 0.12), TC (0.90 ± 0.04; 1.11 ± 0.23; 0.96 ± 0.13), and TN (0.87 ± 0.03; 0.09 ± 0.02; $1.08 \pm 0.1\ 4$). The effectiveness of these validations for other components varied. With larger and more diverse calibrations, NIRS should be capable of predicting important chemical and physical properties in rangeland soils with different land use histories.

STATUS OF MICROBIOTIC SOIL CRUSTS ON THE GRAND STAIRCASE ESCALANTE NATIONAL MONUMENT. David C. Anderson*[1], E. Durant McArthur[2], Heather L. Heaton[3]; [1]Wildland Ecosystem Specalists Team LLC, Scientist, Henderson, NV, [2]Wildland Ecosystem Specalists Team LLC, Lead Scientist, St. George, UT, [3]Kane County, Biological Specialist, Moccasin, AZ

The Grand Staircase Escalante National Monument encompasses 1.9 million acres in the Great Basin and Colorado Plateau of south central Utah. The primary land cover classes are pinyon/juniper woodlands and big sagebrush and blackbrush/Mormon tea shrublands. Annual precipitation ranges from 6" to 11.3" and elevation from 4,000' to 9,000'. Authorized uses within the Monument include oil, gas and coal leases, mining claims, livestock grazing, rights-of-way, hunting, hiking, recreational and scientific activities.

Microbiotic soil crusts are a common resource in the Monument and have garnered recent attention. Their occurrence in arid and semi-arid regions has long been documented and their role(s) in those regions have been the subject of numerous investigations over the past half century yielding mixed or inconclusive results for ecological services.

We initiated a study in 2014 to investigate status of microbiotic soil crusts on the Monument employing a grid sampling methodology (161 sites in 124 grids covering the entire Monument). Data on the status of crusts associated vascular vegetation were collected.

Average vascular plant cover was 9% (range < 1% −39%). Average microbiotic soil crust cover averaged 27%, with a few sites with less than 1% and more than half with over 20% cover. Crust cover was similar over major soil and vegetation types. Three-fourths of the sites showed signs of grazing with average crust cover higher on grazed sites than on ungrazed sites. Soil disturbance from livestock was less than 1% on over 80% of the sample sites. Higher soil crust cover was observed to be associated with lower vascular plant cover.

Microbiotic soil crusts were found on about two thirds of the sampled grids and at different development levels, suggesting current Monument land uses are compatible with crust sustainability. Some areas on the Monument do not support a microbiotic soil crust.

AN AUTOMATED APPROACH TO MAPPING ECOLOGICAL SITES USING HYPER-TEMPORAL REMOTE SENSING AND SVM CLASSIFICATION. Jonathan J. Maynard*, Jason W. Karl; USDA-ARS, Las Cruces, NM

The development of ecological sites as management units has emerged as a highly effective land management framework, but its utility has been limited by spatial ambiguity of ecological site locations in the U.S., lack of ecological site concepts in many other parts of the world, and the inability to accurately assess the state of ecological sites or monitor changes in state through time. Here we present a modeling framework for high-resolution mapping of ecological sites in a semi-arid ecosystem using hyper-temporal remote sensing (i.e., hundreds of images) and support vector machine (SVM) classification. Results from this study show that SVM classification was effective in modeling ecological sites using a 28-year time series of normalized difference vegetation index (NDVI), with a 62% correct classification. Results were compared to Soil Survey Geographic database and expert delineated maps of ecological sites which had a 51 and 89% correct classification, respectively. The hyper-temporal remote sensing framework is effective in modeling the spatial distribution of ecological sites through its ability to characterize the soil-vegetation relationship and its response to climatic variability (i.e., drought or elevated rainfall). Additionally, the proposed hyper-temporal remote sensing technique may provide an objective framework to evaluate and test ecological site concepts through examining differences in vegetation dynamics in response to climatic variability, as well as the ability to assess and monitor changes in ecological state due to other change drivers. Given limited financial and human resources, an improved understanding of ecosystem potential is needed to maximize ecosystem services, promote the recovery of degraded lands, and adapt to and mitigate the impacts of climate change. The hyper-temporal remote sensing approach presented here has potential to greatly improve the efficiency of high-resolution ecological site mapping, and highlights its utility in terms of reduced cost and time investment relative to traditional manual mapping approaches.

RANGELAND INVENTORY AND RANGE IMPROVEMENT PRACTICES OF ALPACA PRODUCTION SYSTEMS IN PERU . Melody R. Zarria, Enrique R. Flores*; Universidad Nacional Agraria La Molina, Lima, Peru

A research study was conducted to assess ecological condition and range improvement priorities of peasants' communities. Three typical alpaca production systems in the Central Sierra of Peru: Communal Cooperatives (CC), Communal Farms (CF) and Livestock Associations (LA) were studied. Results showed that LA and CF rangelands

were in lower condition (fair) than CC (good). Forage balances (Alpaca Units: Al.U) and range trend were positive for CC (0.3 Al.U/ha/yr) and negative for CF and LA (-0.3 and -1.5 Al.U/ha/yr, respectively). Ranchers' perceptions about range management problems and range improvements needs were in general similar among ranchers except for availability of water sources. LA and CC had enough water sources available for livestock whereas lack of water was a significant problem for CF. When range managers were asked to rank management problems and range improvement needs, they indicated lack water developments and overgrazing as the two main problems affecting alpaca production whereas paddock fencing, establishment of irrigation systems, and technical training were considered key range improvement needs.

Symposium:
Role of Genetic Approaches and Breeding Native Plant Cultivars for Rangeland Restoration

GENETICS AND NICHE MODELLING TO GUIDE RESTORATION IN A CHANGING CLIMATE. Bryce A. Richardson*; USDA Forest Service, Provo, UT

Sagebrush ecosystems and the flora and fauna they support are under threat. These threats are especially formidable for Wyoming big sagebrush, occupying the warmer-drier spectrum of these ecosystems. Loss of sagebrush has been the result of disturbance and weed encroachment; however, another underlying and increasingly important factor is climate change. Climate change information has to be an integral part of both research and management. For some areas of sagebrush, the notion of restoring to pre-disturbance conditions may be flawed. For example, the climatic niche of Wyoming big sagebrush is expected to decrease by about one-third by 2060 with much of the predicted loss occurring in the Great Basin. Moreover, niche modeling of ecoregions suggest southern and lower elevations of the sagebrush ecosystem will become ecotonal or transition to Mojave Desert. To mitigate the effects of climate change, disturbance and weeds, research should consider: 1) what native species will be suitable for future climates, 2) whether these species bear life-history characters and traits that would make them competitive against weeds, and 3) which populations within these species would be best adapted for assisted migration. I will discuss potential candidate species for assisted migration to fill the void left by sagebrush, populations that could provide higher fitness, and finally, the context and the potential role of breeding.

USING NEXT-GENERATION SEAQUENCING DATA TO INVESTIGATE POPULATION STRUCTURE AND LOCAL ADAPTATION: A CASE STUDY IN *SYNTRICHIA (TORTULA)) RURALIS*, AN IMPORTANT COMPONENT OF BIOLOGICAL SOIL CRUSTS. Robert T. Massatti*; US Geological Survey, Flagstaff, AZ

Biological soil crusts are foundational to natural ecosystem function in semi-arid regions of the world, including the Western U.S. They are composed of phyletically diverse organisms, including microbes, green algae, lichens, and mosses. While diminutive, these assemblages have a large ecological impact - for example, they stabilize soil, fix nitrogen, and store water, nutrients, and organic matter. Importantly, these functions facilitate the establishment of vascular plants. Biocrusts are extremely susceptible to mechanical disturbance and thus have been depleted throughout the semi-arid West. As a result, restoration of functional ecosystems in the West may often depend on the re-establishment of biocrust communities. However, successful restoration must anticipate often extreme environmental gradients, for example the decreasing intensity of monsoonal precipitation on the Colorado Plateau from the Mogollon Rim to the Uinta Basin. Such gradients are expected to select for locally adapted genotypes; consequently, materials for restoration should be sourced carefully to optimize restoration outcomes. Sourcing may be especially important for biocrust mosses, including the widely distributed *Syntrichia ruralis,* which are predominantly asexual and thus may be less able to respond to selection imposed at a restoration site or during materials development. To expand our basic knowledge of biocrusts and gain insight into how best to restore them, we used next-generation sequencing to genotype *Syntrichia ruralis* populations collected across the monsoonal gradient of the Colorado Plateau. We found that populations exhibit significant genetic differentiation, and present evidence that some of this differentiation may reflect local adaptation. The genetic techniques employed here provide a promising and cost-effective mechanism to characterize genetic differentiation and diversity of restoration species, and they may prove to be useful tools to guide future restoration efforts.

ESTABLISHMENT OF NATIVE PERENNIAL GRASS SPECIES AND VARIETIES IN RANGELAND SEEDING. Kevin B. Jensen*[1], Joseph G. Robins[2], Craig Rigby[1], Thomas A. Jones[3], Blair L. Waldron[1]; [1]Forage and Range Research Lab, Logan, UT, [2]USDA ARS, Logan, UT, [3]USDA Agriculture Research Service, Logan, UT

As a result of wildfire, livestock, wildlife, human activities, and drier hotter growing conditions, lower-elevation Basin and Wyoming big sagebrush rangelands have undergone large-scale conversion from a diverse, healthy perennial plant-dominated ecosystems to near monocultures of invasive annual grasses, particularly, cheatgrass and medusahead. Seedling establishment and plant persistence are of paramount importance to a successful rangeland seeding. Historically in the early 1900's and continued through much of the 19th century, revegetation efforts focused on the use of introduced grasses such as crested wheatgrass and Siberian wheatgrass because of their superior stand establishment, plant persistence, and competitive ability to suppress invasive annual grasses under dry hot environments receiving less than 300 mm average annual precipitation. With the increased emphasis in the last decade to utilize native species in rangeland restoration seedings, plant breeding efforts have focused on seed yield, seedling establishment, persistence, and competitiveness in the following species; bottlebrush squirreltail, basin wildrye, slender wheatgrass, bluebunch wheatgrass, Snake River wheatgrass, thickspike wheatgrass, Sandberg bluegrass, and

western wheatgrass. Across multiple rangeland locations, the newer varieties in most instances had increased seedling frequency vs. older varieties. Examples will be given that describes plant selection and subsequent improvement compared to the unimproved plant materials.

NEW WOODY PLANT CULTIVARS AND SUSTAINABLE URBAN LANDSCAPING. Larry A. Rupp*; Utah State University, Logan, UT

Constructed landscapes are the default ecosystem for most urban residents of the American Southwest and provide welcome environmental and aesthetic benefits.   However, such landscaping is increasingly viewed as unsustainable due to its demand for water and other resources. Efforts to increase sustainability range from artificial to completely natural landscapes that address reduced resource use, but often fail to recognize the quality of life provided by traditional landscaping and its importance in the urban environment.

Woody plant development for horticultural crop production has historically focused on the selection and use of superior, asexually propagated clones. While the use of such cultivars leads to monocultures and the problems of decreased genetic diversity, the advantages of characteristics such as fruit quality and uniform harvest dates in a managed environment far outweigh the potential disadvantages. The benefits of woody plant cultivars also extend to landscaping and are seen in the use of plants with superior traits that also meet the demands of landscape architects and homeowners for a product that is consistently both true-to-name and true-to-type.

The need for sustainable urban landscaping is driving a demand for the use of adapted, native plants. When used appropriately, native woody plants offer a sustainable alternative to less adapted exotic plants in the constructed landscape. However, being native is not enough. Such plants should also be selected for superior landscape characteristics such as fall color and/or disease resistance; identified as named cultivars; and propagated clonally.   The combination of both native adaptation and superior horticultural traits holds the greatest promise for the use of native plants to increase the sustainability of our landscapes. In turn, such landscapes will further enable conservation of resources while maintaining quality of life.

REINTRODUCTION OF THE AMERICAN CHESTNUT: IMPACTS OF TRADITIONAL BREEDING AND FOREST MANAGEMENT IN RESTORATION OF AN EXTIRPATED SPECIES. Stacy Clark*; USDA Forest Service, Knoxville, TN

The American chestnut (*Castanea dentata*) was an iconic tree in the eastern United States, valued for its lumber, edible mast, and tannin. The species was a common component within its 200 million acre range that stretched from southern Ontario to Mississippi. American chestnut was a keystone species, providing important dietary

needs and habitat for numerous insects, birds, and mammals. The tree was ecologically extirpated by exotic pests from Asia, notably, the chestnut blight (*Cryphonectria parasitica*) by the early 20th century. The loss of the American chestnut probably had devastating consequences on the ecosystem, although research was not being widely conducted at the time. A backcross breeding approach that transfers resistant genes from Asian chestnut species to the American chestnut while retaining American chestnut growth characteristics was first tested in a series of experimental forest plantings from 2009 to 2014 on USDA National Forest System lands. Trees were challenged by biological factors, primarily deer browse and root rot disease (causal agent *Phytophthora cinnamomi*) that limited survival and growth. Blight resistance was affected by the interaction of breeding and planting location. The breeding generation with putative blight resistance (BC3F3) exhibited better resistance than the American chestnut, but were not as resistance as the Chinese chestnut (*C. mollissima*) at some locations. Growth of BC3F3 seedlings was less than American chestnut seedlings at some locations, indicating a departure from desired traits. Success was affected by seedling characteristics at the time of planting, primarily size of seedlings, with larger seedlings exhibiting better growth over time. Results indicate that blight resistance is one of a multitude of interrelated factors affecting success of American chestnut restoration. A multi-disciplinary approach to research and restoration is required, but will be limited by available technological and administrative resources.

GENETIC CONTROL OF PLANT INTERACTIONS: CONTINUED DEVELOPMENT OF BLUEBUNCH WHEATGRASS FOR THE GREAT BASIN. Blair L. Waldron*[1], Steve R. Larson[2], Danny Summers[3]; [1]USDA-ARS, Logan, UT, [2]USDA Agriculture Research Service, Logan, UT, [3]Utah Division of Wildlife Resources, Ephraim, UT

Diverse plant communities have been shown to enhance ecological function. It has been hypothesized, that the ecological combining ability between grasses and forbs can be improved by selecting genotypes specifically for compatibility in a mixture. Our research has recently explored this hypothesis and shown that the genetic control of grass growth response in a mixture with legumes is different than that exhibited when grown in a monoculture. These results have implications for the future development of grasses used for rangeland restoration. Bluebunch wheatgrass is one such important native species used in many reseeding efforts of the Great Basin. The varieties used in these reseedings usually originate from the Palouse region, but increased interest to restore rangelands using regionally-adapted plant germplasm necessitates the development of Great Basin ecosytem-originated bluebunch wheatgrass. However, the dramatic and substantial degradation of this region, caused by invasive weeds and changed fire regimes, could seriously challenge the successful use of "local" seed sources and germplasms. Alternatively, Great Basin-originated varieties with enhanced adaptation to this changed environment, either through natural selection or plant breeding, could play a critical role in restoration of this region. This paper will discuss how the strategies of molecular genetics, seed transfer zones, and enhanced adaptation and mixture compatibility are being employed in our ongoing development of Great Basin-originated bluebunch wheatgrass varieties.

IMPROVEMENT EFFORTS IN SWEETVETCH (*HEDYSARUM BOREALE*). Michael D. Peel*[1], Blair L. Waldron[2], Ivan W. Mott[1]; [1]USDA ARS, Logan, UT, [2]Forage and Range Research Lab, Logan, UT

Sweetvetch (*Hedysarum boreale* Nutt.), a legume native to the western USA and Canada, use in reseeding is often limited by seed production. The lack of seed production is limited by genetic factors as well as production knowledge. To address this we: 1) Developed a growth stage and heat unit model that designates 14 finite stages, V1 through V6 (vegetative), and R1 through R8 (reproductive stages). This system provides meaningful designations for management of the plant for seed production, with a base temperature of 40° F (4.4° C). 2) We demonstrated that sweetvetch is tolerant to glyphosate in vegetative stages demonstrated by an LD50 value of 3,467 g ae ha-1, and GR15 values of 670 g ae ha-1. 3) Through recurrent selection seed production was been increased fourfold and seed shatter reduced relative to Timp the only available cultivar. In addition the forage nutritive value parameters of crude protein and neutral detergent fiber have been shown to compare favorably with alfalfa and sainfoin and even exceed both at early growth stages.

A NATURAL GENE VARIANT THAT IMPROVES SEED RETENTION AND SEED GERMINATION IN NATIVE GRASSES. Steve R. Larson*, Thomas A. Jones; USDA Agriculture Research Service, Logan, UT

Complex genetic and environmental factors interact to promote variation in the timing of seed ripening, seed abscission, and seed germination processes that enable wild plants to distribute their chances for recruitment. However, native grass seed producers must harvest seed before it shatters, which may negatively impact seed germination and plant establishment if the seeds are not fully ripened. Basin wildrye (BWR) is considered the largest native grass in western North America, and it is widely used in rangeland seeding mixtures. Unlike crested wheatgrass, which has been successfully planted across U.S. rangelands, BWR is prone to rapid seed shattering and often displays poor seedling establishment. Creeping wildrye (CWR) is closely related to BWR, but it has strong seed retention similar to crested wheatgrass. Genetic analysis of CWR x BWR hybrids indicated that seed retention is controlled by one recessive gene. Isogenic BWR backcross populations were used to compare the effect of the CWR seed retention gene over a course of 70 days, from July 16 to September 21, on seed yield and seed germination. Seed yields (mg per inflorescence) decreased from about 45 mg on the first harvest date to 10 mg on the last harvest date for plants containing the BWR seed shattering gene, whereas plants carrying the CWR gene retained an average of 39 mg on the last harvest date. Moreover, the time required for 50% of the seeds to germinate decreased geometrically from 19 days on the first harvest date to 11 days on the last harvest date. These results demonstrate that the processes of seed ripening and seed disarticulation are highly coordinated and that germination rates are reduced if seeds are

harvested before they begin to shatter. Germplasm with increased seed retention, yield, and germination rates may be valuable for restoring native plant populations.

Oral Technical Session:
Fire Ecology and Management:

MOJAVE DESERT PRECIPITATION REGIMES AND FIRE OCCURRENCE. Jerry Tagestad*[1], Matthew Brooks[2], Valerie Cullinan[3], Janelle L. Downs[4], Randy McKinley[5]; [1]PNNL, Richland, WA, [2]USGS, Sacramento, CA, [3]Coastal Sciences Division, Sequim, WA, [4]Pacific Northwest National Laboratory, Richland, WA, [5]USGS, Sioux Falls, SD

The objective of this study was to characterize precipitation patterns and their relationship to fire occurrence in the Mojave Desert. To develop an understanding of recent precipitation regimes we classified monthly precipitation maps from 1971-2010 into four discrete zones defined by the magnitude and timing of precipitation: low winter/low summer, moderate winter/moderate summer, high winter/low summer and high winter/high summer. We found that the two regimes with moderate and high summer precipitation covered less than half of the ecoregion yet contained 88% of the area burned and 95% of the area of repeat burns. To determine if precipitation regime boundaries shift due to extended periods of drought or above average precipitation, we applied the regime classification to historic monthly data for early-century (wet period) and mid-century (drought) periods. The early-century precipitation regimes are quite similar to current, while the mid-century results show sizeable shift in the precipitation regime boundaries with a large reduction in area of monsoonal effect. Anecdotal records of fire occurrence show that the mid-century period had a low occurrence of fire. To infer potential future fire occurrence we assessed downscaled precipitation from global climate models for 2010-2099. The selected climate models suggest numerous extended periods of high precipitation across the ecoregion. These results would suggest higher fire potential in the middle and high-elevation areas of the ecoregion for many multi-decade periods during the next century.

EFFECTS OF GRAZING AND SEASON ON FUEL CHARACTERISTICS, FIRE IGNITIBILITY AND SPREAD. Amanda Gearhart*[1], Kirk W. Davies[2], Jonathan Bates[3], Chad Boyd[1]; [1]USDA-Agricultural Research Service, Burns, OR, [2]USDA - Agricultural Research Service, Burns, OR, [3]USDA-ARS, Burns, OR

Wildfire is one of the main threats to the conservation of sagebrush steppe plant communities. Annually wildfires burn approximately 7.2 million acres of rangelands and average $1.5 billion in suppression costs in the past decade. Fires degrade wildlife habitat and threaten the livelihood of livestock producers. Preservation of sagebrush dominated communities is imperative and this may include fuels management. However, because of the spatial extent of sagebrush rangelands, grazing is likely the only feasible treatment to manage fuels effectively. We investigated the effect of season of grazing (spring grazing, fall grazing, and no grazing) with moderate utilization on fuel characteristics and fire

ignitibility and spread during the active wildfire season (June – August). Grazing by cattle reduced fine fuel continuity and increased fuel moisture by reducing senescent herbaceous material. Ignitibility and spread was greater in the no grazing treatment compared with both grazing treatments.

EFFECTS OF MULCH ON PLANT AND SOIL RECOVERY AFTER WILDFIRE IN THE EASTERN GREAT BASIN. Camie M. Dencker*[1], Jeffrey M. Gicklhorn[2], Lara D. Derasary[3], Beth A. Newingham[4]; [1]University of Nevada, Reno / USDA ARS Reno, Reno, NV, [2]University of Nevada Reno, Reno, NV, [3]Eastern Nevada Landscape Coalition, Ely, NV, [4]USDA-ARS, Reno, NV

Straw mulch is often applied after wildfire to reduce soil erosion and potentially increase soil moisture and thus plant recruitment. However, the efficacy of mulch treatments is poorly known, particularly in Great Basin ecosystems. We examined the effects of straw mulch application on the Black fire, which burned in July 2013 near Great Basin National Park. Straw mulch treatments were aerially applied on a south- and east-facing slope. Canopy and ground cover, plant density, basal and canopy gaps, and soil stability were measured at both sites in 2014, 2015 and 2016 in mulched and control areas. Canopy cover increased and canopy gap decreased from 2014 to 2016. Bareground decreased at all sites from 2014 to 2015, while only south-facing sites continued to decrease in 2016. Basal gap increased in treated sites from 2014 to 2016. Soil stability declined in treated sites after three years. Mulch significantly increased canopy cover, decreased basal gap and bareground, but had no effect on canopy gap. The surprising increase in basal gap with mulch application over time may be due to mulch washing or blowing away or being incorporated into the soil surface. Our results suggest that post-fire mulch application promotes vegetative growth and decreases bareground and soil stability over time. Therefore, additional methods should be considered for restoration treatments seeking to stabilize soils.

SOCIO-ECOLOGICAL CHALLENGES IN UNDERSTANDING FIRE DYNAMICS AND WOODLAND EXPANSION IN THE GREAT PLAINS, USA. Rheinhardt Scholtz*[1], Sam Fuhlendorf[1], Steven Archer[2]; [1]Oklahoma State University, Stillwater, OK, [2]University of Arizona, Tucson, AZ

Woody encroachment is a global phenomenon on numerous continents (e.g. Africa, Australia, N. America). In North American grasslands, managing tree/shrub proliferation has been challenging, as its causes are varied and actively debated. Social factors (e.g. culturally-ingrained differences in the use of prescribed fire) have contributed to woodland expansion but are seldom factored in to ecological models. Great Plains grasslands are largely comprised of private lands. This, coupled with a lack of consistent fire policy within and across state boundaries, has led to high spatial variability of fire. We used fire occurrence data (1984 – 2012) from N. Dakota to Texas to identify areas with relatively low (<0.65) and high (>0.65) fire probabilities. We aimed to predict how

potential woody cover and stature (key surrogates for biomass and C-mass) vary as a function of fire x climate interactions in these contrasting areas. Results suggest that woody plant height is largely dictated by mean annual precipitation (MAP). However, under low and high fire regimes, their height was restrained to ~3m and ~5 m in areas receiving ≤800mm and ≤1050mm MAP, respectively. In contrast to height, % cover was mainly predicted by mean annual temperature (MAT). Here, warmer areas (e.g. Texas) had greater woody cover than cooler areas (e.g. Kansas) with no consistent relationship with fire and MAP. Overall, MAP, MAT and social constructs (e.g. landowner, burn associations) were the main predictors of fire dynamics. Understanding the interactions between these variables will allow us to better predict areas of future woodland expansion.

LAWS DRIVE GRASSLAND TRANSITION TO EASTERN REDCEDAR WOODLAND. Carissa L. Wonkka*, Dirac Twidwell; University of Nebraska - Lincoln, Lincoln, NE

Eastern redcedar has invaded grasslands across the central United States, transforming vast areas of productive grassland into cedar forest. This biome-level transformation is threatening the sustainability and profitability of livestock production, precipitating declines in grassland wildlife, reducing available water resources, and threatening human safety by increasing wildfire danger. Eastern redcedar invasion has been linked to a reduction in the intensity and spatial extent of fires following European settlement of the Great Plains, which is the result of changes in human use of fire in the region. Human fire use varies relative to societal norms and policies regarding fire use, which determine conditions under which fire management can occur and the resulting range in fire intensities and scales of application available for meeting management goals. Given this, laws could be a major driver of patterns of Eastern redcedar invasion in the Great Plains. We developed a simulation model to explore the influence of specific laws on Eastern redcedar invasion in the Great Plains. This modeling exercise identified laws and policies that influence fire management as major drivers of the rate and extent of transition from grassland to cedar forest. For instance: 1) stringent liability standards decrease the number of managers who are willing to burn, thereby decreasing the spatial extent of fire in an area and allowing greater spread of redcedar into uninvaded areas 2) burning restrictions during periods of drought limit opportunities to burn under conditions where high fire intensities and attendant reductions in cover of mature redcedar can be acheived. Understanding the effects of laws and policies on redcedar invasion is necessary to assess trade-offs associated with legislatively limiting the scale and intensity of fire available to mangers and to avoid unintended consequences when developing legislation aimed at protecting grassland species.

EFFECTS OF FUELS MANAGEMENT TECHNIQUES ON FIRE SUPPRESSION CAPABILITY AND PRAIRIE-CHICKEN HABITAT. Heath D. Starns*[1], R. Dwayne Elmore[1], Sam Fuhlendorf[1], Torre J. Hovick[2], Eric T. Thacker[3], Dirac

Twidwell[4]; [1]Oklahoma State University, Stillwater, OK, [2]North Dakota State University, Fargo, ND, [3]Utah State University, Logan, UT, [4]University of Nebraska - Lincoln, Lincoln, NE

Grasslands of the southern Great Plains have suffered a reduction in diversity due to long-term exclusion of fire from the region. An additional consequence of fire suppression has been a recent increase in the occurrence and impact of wildfires. Our study compared the effects of patch-burning to prescribed fire alone on vegetation structure and rate of biomass accumulation in the southern Great Plains. Four vegetation types are represented by four sites across Texas and Oklahoma. All sites are within the historic or current distribution of lesser (*T. pallidicinctus*), greater (*T. cupido cupido*), or Attwater's prairie-chickens (*T. c. attwateri*). We measured vegetation characteristics in patches with different time-since-fire at each site in order to simulate fire behavior and assess structural characteristics relative to prairie-chicken habitat. Patch-burning maintained simulated fire intensities at or below a critical threshold of 3.4 meters for up to 36 months post-fire, compared to six months for sites treated with fire alone. Time-since-fire also impacted vegetation height and community composition, suggesting patch-burning provides for structural diversity of vegetation. Our data indicate patch-burning is a viable strategy for conservation-oriented fuels management. Implementation of patch-burning in the southern Great Plains would extend fire suppression capabilities and improve wildland firefighter safety. Patch-burning also increases heterogeneity of vegetation at the landscape scale, which is a key habitat requirement of prairie-chickens. Moreover, because of the diverse habitat requirements of prairie-chickens, patch-burning would likely benefit other Great Plains species.

FUEL LOAD AND BURN SEASON EFFECTS ON *SERICEA LESPEDEZA* GROWTH AND REPRODUCTION.

Brenda A. Koerner*, Erin E. Lingenfelter; Emporia State University, Emporia, KS

Sericea lespedeza is an invasive plant expanding its range through the grasslands of the Great Plains, displacing native grasses and reducing plant diversity. Given the historical loss of grasslands and the economic cost of invasive species, it is important to find sustainable management options. We evaluated the effect of burn season in conjunction with other common management strategies on the reduction of *Sericea lespedeza*. Our burn treatments included spring burn, fall burn and unburned plots that were subdivided to receive a secondary treatment of herbicide, mowing, fuel load addition, or burn only. Individual plants were marked within each burn treatment and secondary treatment. At the end of the growing season prior to the burn treatments and in the following year after the burn treatments, aboveground standing biomass, stem height, stem number, and seed production were measured. Results indicate that fall burning in conjunction with mowing results in the greatest reduction of stem height, seed weight, and plant biomass. Mowing after a fall fire appears to have the greatest impact on reducing seed production. The investment in seed production was reduced in plants after fall fire compared to spring fire regardless of secondary treatment. Because *Sericea lespedeza* is a prolific seed producer, the reduced investment in seed production is

important for its control. This study shows that fall fire, especially in conjunction with mowing treatments, can significantly reduce seed production of *Sericea lespedeza*.

RESTORATION OF A RANGELAND ECOREGION WITH EXTREME FIRE. Dirac Twidwell*[1], Craig R. Allen[2], Christine Bielski[2], Brittany Dueker[2], Helen Tripp[2], Zachary Walton[2], Carissa L. Wonkka[3]; [1]University of Nebraska, Institute of Agriculture and Natural Resources, Lincoln, NE, [2]University of Nebraska, Lincoln, NE, [3]University of Nebraska - Lincoln, Lincoln, NE

Restoration success has often been described as overcoming the resilience of an undesirable ecological state and promoting a more desirable one that provides greater ecosystem services to society. Yet, operationalizing resilience in this way does not explicitly account for scale and the logistical and economical constraints that preclude restoration success at broader scales. For example, mechanical removal of *Juniperus* spp. that have invaded into Great Plains grasslands is the preferred restoration option but has been too costly to meet the scale of invasion. Restoration success is limited to small acreages, allowing *Juniperus* trees to invade into surrounding landscapes. Shifts from grassland to juniper dominance is now a pervasive issue across multiple Great Plains states, and questions on how to scale up restoration success has emerged as a focal issue. In this paper, I introduce findings from the Loess Canyon Experimental Landscape (LCEL), an innovative approach to rangeland restoration that centers on the use of extreme fire to restore grassland dominance in an ecoregion that has been converted to *Juniperus* woodland. The LCEL is a partnership between the Applied Complex Adaptive Systems Lab at the University of Nebraska and the Loess Canyon Rangeland Alliance, a landowner prescribed burn cooperative that is using extreme fires to restore grassland dominance in woody invaded rangelands across 180,000 contiguous acres. This experimental landscape is now the largest scale restoration of high intensity fires as a fundamental component of rangeland management in the entire Great Plains biome, and we present early evidence indicating that multiple ecosystem services are being enhanced as a result of this restoration effort.

IMPACT OF RANGELAND FIRE ON DUNG BEETLES OF THE TEXAS ROLLING PLAINS. Britt Smith*, Robin Verble-Pearson, Brad Dabbert; Texas Tech University, Lubbock, TX

Dung beetles are ecologically and economically important insects in rangeland ecosystems. They recycle nutrients, reduce livestock parasites, and are a food source for some wildlife species. Fire is a common management tool to control brush and improve forage in rangelands. The influence of prescribed rangeland fire on the dung beetle community in the United States is an understudied issue. Burning can influence grazing animal distribution since grazing animals are attracted to regrowing forage. As a result, grazing animals create a strong contrast in vegetation structure between burned and unburned areas. This aggregation of grazing animals and contrast in vegetation structure

may influence dung beetle abundance in recently burned areas. Our study was conducted June 9th – 16th, 2015 and June 20th – 26th, 2016 at Matador Wildlife Management Area within the Texas Rolling Plains. Three spring prescribed burns were conducted in 2015 and 2016. We established six sample locations across the three burned areas each year. Each sampling location contained four baited pitfall traps with two in the burned area and two in the adjacent unburned area. Traps were collected daily for six days. Trap bait was replaced every other day. Nine taxa of dung beetles were identified in 2015. Covariates examined included treatment, vegetation visual obstruction, and dung density. In 2015, we did not observe a significant difference between taxon abundance and covariates. Also, though not significant, *Canthon spp* were marginally more abundant on unburned areas. Samples for 2016 are currently being identified and counted.

Oral Technical Session:
Invasive Species Management and Monitoring

POST-FIRE GRAZING MANAGEMENT IN THE PRESENCE OF CHEATGRASS: A NEVADA SIMULATED AND NATURAL GRAZING EXPERIMENT. Devon K. Snyder*[1], Tamzen K. Stringham[2]; [1]University of Nevada Reno, Reno, NV, [2]University of Nevada, Reno, Reno, NV

The decision of when and how to graze after a wildfire should be based on ecological site and condition of the management unit. Sites dominated by annual grasses may be ideal locations for proactive fuels management practices such as targeted grazing (Murphy et al. 2013), yet there are limited data available to inform managers of the ecological effects of these practices. This research aims to provide ecologically-based understanding of the effects of various grazing management strategies on a recently-burned rangeland. Five exclosure plots were established within one Disturbance Response Group (DRG) near McDermitt, Nevada to examine effects of cow-calf spring grazing, simulated spring grazing, simulated fall grazing, and rest (control) on vegetative response Treatments were applied manually using weed eaters in May/June for spring treatments and September/October for fall treatments. Measurements were taken on vegetation composition, basal gap, annual production, and density of shrub seedlings. The vegetation was largely comprised of Sandberg bluegrass (*Poa secunda*) but had a component of cheatgrass (*Bromus tectorum)* that increased over the four-year study period. A seedbank study was completed to enhance understanding of cheatgrass in the system. We now have four years of results showing plant community response to different lengths of rest, different seasons of use after fire, and interactions with climate variables. Coupling project results with ecological site descriptions and state-and-transition models will help land managers stratify post-fire management decisions across large landscapes based on pre-fire condition, measured plant community response, and quantified ecological thresholds.

PRACTICAL AND EFFECTIVE REHABILITATION OF RANGELANDS: LESSONS LEARNED. Charlie D. Clements*, Dan Harmon; USDA-ARS, Reno, NV

Disturbed rangelands present significant challenges to land managers and private land owners. Controversy exists on the approach as to how to restore or rehabilitate these degraded rangelands. The proper use of plant materials and aggressive weed control practices can significantly increase the success of rehabilitation efforts on rangelands. Discing cheatgrass dominated habitats in the spring prior to cheatgrass flowering decreased cheatgrass above-ground densities by as much as 73% which contributed to an increase in seeded species success. The use of soil active herbicides controlled above-ground cheatgrass densities by as much as 98.7% and increased seeded species success by nearly 300%. Understanding that as little as 4 cheatgrass plants/ft² can outcompete perennial grass seedlings gives rise to the level of cheatgrass control needed to successfully seed perennial grasses. Understanding the role that granivorous rodents play in the harvesting and consumption of seeds is also beneficial in selecting plant materials for selected sites. Transplanting of certain shrub species, such as big sagebrush, is a method that can produce excellent results, especially if transplanted in the fall where we experienced an average of 57% success versus 28% for spring transplants. The active management of these treated lands is an ongoing effort to enhance habitats for wildlife and grazing resources.

EVALUATING THE USE OF THRESHOLDS CONCEPTS FOR IMPROVING HABITAT THROUGH CHEATGRASS MANAGEMENT. Clay W. Wood*[1], Brian A. Mealor[2]; [1]University of Wyoming, Laramie, WY, [2]University of Wyoming, Sheridan, WY

Invasive species have an ever-increasing impact on the ecological and economic functions of ecosystems. Cheatgrass (*Bromus tectorum*) is an invasive annual grass that is widely distributed throughout most of the western United States. Cheatgrass produces high amounts of fine fuels that can increase fire frequency and severity, altering vegetation composition and structure. Although cheatgrass can be used as early spring forage for livestock and wildlife, it may not be preferred, and therefore its suitability as a forage is questionable. The objective of this research is to determine if there is a direct, predictable relationship between pre-treatment vegetation condition and post-treatment increases in perennial grass biomass and other vegetation characteristics following treatment with two formulations of imazapic (liquid and granular). We sampled locations representing a gradient of cheatgrass to perennial grass biomass and canopy cover ratios prior to, and following, herbicide application across multiple sites. At each intensively sampled location we employed four different sampling methods to determine the ratio of cheatgrass to perennial grass using both biomass and cover. At the Saratoga and Pinedale, Wyoming field sites, we collected pre-treatment data in 2015, aerially applied herbicides in September 2015, and collected post-treatment data in 2016. Initial post-treatment results indicate that both herbicide formulations reduced cheatgrass cover. Preliminary data analyses suggest the ability to identify cheatgrass abundances at which an increase in perennial grass biomass in response to herbicide treatment may be

expected, but inter-annual variability in vegetation poses challenges. Post-treatment data will be collected on all sites in 2017, including two additional field sites near Sheridan and Hyattville, Wyoming sampled and treated in 2016, to further evaluate the response of cheatgrass and associated vegetation following imazapic application for cheatgrass control.

MAPPING CHEATGRASS OCCURRENCE ACROSS THE HISTORIC RANGE OF SAGE GROUSE. Kyle B. Larson*[1], Janelle L. Downs[1], Valerie Cullinan[2]; [1]Pacific Northwest National Laboratory, Richland, WA, [2]Coastal Sciences Division, Sequim, WA

The spread of invasive annual grasses, such as cheatgrass (Bromus tectorum), can contribute to increased size and frequency of wildfires in western rangelands, posing a significant threat to human use and sensitive wildlife species such as the Greater sage-grouse (Centrocercus urophasianus). Knowledge of the current distribution of cheatgrass is a key component in strategies to mitigate wildfire, reduce the spread of cheatgrass, and protect sage-grouse habitat. We assembled over 24,000 field measurements of cheatgrass cover from various sources to support development of a Generalized Additive Model to predict the spatial extent of cheatgrass across the historic range of sage-grouse in the U.S. (~288 million acres). We focused on identifying areas with >2 percent cheatgrass cover because a strong statistical separation was observed in the field data at this value. A total of 50 climatic, biophysical, and remote sensing variables were examined for statistical significance. Using a forward-stepping selection process, 13 variables were retained for inclusion in the predictive model, including a temporally disaggregated peak NDVI (Normalized Difference Vegetation Index) for years of above-average winter precipitation that was derived to account for regional differences in cheatgrass growth across the broad geographic area. The model correctly classified cheatgrass occurrence at 71% of field measurements reserved for validation. The spatial interpolation of the model indicates that approximately 60.3 million acres within the historic range of sage-grouse has been invaded by cheatgrass, with more extensive invasion in the Great Basin, Columbia Plateau, Snake River Plain, and Colorado Plateau ecoregions. The spatial data of cheatgrass occurrence produced in this study is intended to help inform landscape-scale management of cheatgrass within non-forested rangelands currently and formerly occupied by sage-grouse, and may be useful for guiding more detailed assessments of cheatgrass distribution and abundance in areas of management concern.

AN ADAPTIVE APPROACH TO MANAGING INTRODUCED COOL-SEASON GGRASSES – LOCAL AND LANDSCAPE SCALE PERSPECTIVES. Cami Dixon*[1], Kristine Askerooth[2], Jill Gannon[3], Clint Moore[4], Terry Shaffer[5], Pauline Drobney[6], Vanessa Fields[7], Todd Frerichs[8], Todd Grant[9], Sara Vacek[10], Jennifer Zorn[11]; [1]U. S. Fish and Wildlife Service, Woodworth, ND, [2]U.S. Fish and Wildlife Service, Cayuga, ND, [3]U.S. Fish and Wildlife Service, Fort Collins, CO, [4]U.S. Geological Survey, Athens, GA, [5]U.S. Geological Survey, Jamestown, ND, [6]U.S. Fish and Wildlife Service, Prairie City, IA, [7]U.S. Fish and Wildlife Service, Great Falls, MT, [8]U.S. Fish and Wildlife

Service, Coleharbor, ND, [9]U.S. Fish and Wildlife Service, Upham, ND, [10]U.S. Fish and Wildlife Service, Morris, MN, [11]U.S. Fish and Wildlife Service, Kenmare, ND

The loss and degradation of North America's grasslands present a formidable challenge to managers attempting to conserve this ecosystem. Much of the mixed-grass and tallgrass prairies managed by the U.S. Fish and Wildlife Service (Service) in the northern Great Plains are invaded by introduced cool-season grasses. Management to suppress these plants has had poor to inconsistent success, mainly for lack of understanding of prairie restoration ecology and absence of systematic evaluation of management effects. The central challenge to land managers is selecting appropriate management actions in the face of biological and environmental uncertainties. In partnership with U.S. Geological Survey, Service staff are implementing an adaptive framework known as the Native Prairie Adaptive Management program (NPAM) that assists managers in selecting management actions under uncertainty and maximizing learning from management outcomes. More than 20 Service stations are involved across the northern Great Plains with a shared goal of increasing native prairie composition.

The framework provides optimal management recommendations based on current knowledge, while incorporating the current condition of enrolled units. The responsibility of managing, monitoring, and data entry lie with the individual station managers; however archiving and analyses are provided at a broader scale through the framework. Station managers recognize that receiving science-based decision support provides efficiencies for NPAM and other units. The NPAM program coordinator possesses a slightly differing perspective by providing operational and oversight tasks. This individual possesses a broad perspective, comprehending the benefits of a collective effort at a landscape scale. An individual management outcome may be unfavorable in a particular year; however the learning that has occurred supersedes this outcome by providing feedback to provide better decisions in the future. Upholding the scientific basis of NPAM and navigating the necessary communications among participants and the coordinator is critical for the long term viability of this program.

RUSSIAN OLIVE INVASION: HOW SOIL PROPERTIES AFFECT INVASION DYNAMICS AND SUCCESSION FOLLOWING MANAGEMENT INPUTS. Merilynn Schantz*[1], Erin Espeland[2], Jennifer Muscha[3], Mark Petersen[4]; [1]Miles Community College/Red Rock Resources LLC, Miles City, MT, [2]USDA-ARS, Sidney, MT, [3]USDA-ARS Fort Keogh, Miles City, MT, [4]USDA-ARS, Miles City, MT

Invasive species, like Russian olive (*Elaeagnus angustifolia* L.), readily prevail along riparian areas of arid ecosystems due in part to the high use of these areas and because of high invasive species seed output and reproductive success along waterways. Once established, Russian olive can reduce native plant cover and density, especially of species growing under its canopy. However, little is known about the effects of Russian olive management inputs, like plant removal, on riparian plant community succession in spatially diverse communities, like riverbanks. Our objectives were to evaluate how spatial heterogeneity of soils affects plant community structure throughout riparian areas

and identify the effects of plant removal on plant community structure. Here we present the initial results of two studies completed along the Yellowstone River in the Northern Great Plains. We used JMP (JMP v.13, SAS Institute Inc., Cary, NC) to partition data by foliar and basal plant cover and classify similar plant communities followed by a discriminant analysis to identify how these plant communities differed by soil properties, like texture and soil nutrient availability. This analysis revealed three distinct plant communities that exist along the Yellowstone River; Cottonwood, Russian olive closed canopy, and Russian olive open canopy ($p<0.0001$). Next we tracked these communities over three growing seasons following Russian olive removal (2014-2016). We identified that the succession of these communities were strongly driven by year ($p<0.05$), treatment (tree removal or control) ($p<0.0001$) and soil type ($p<0.05$). Specifically, the cover of invasive perennial grasses and native shrubs increased from 2014-2016 ($p<0.0001$), especially when trees were removed and in sandy soils ($p<0.05$); while the cover of native perennial grasses was non-significantly higher in clay soils ($p=0.12$). Based upon these results, we suggest that when Russian olive is removed in sandy soils, invasive perennial grasses should also be controlled at these sites.

TARGETED CATTLE GRAZING TO SUPPRESS SPOTTED KNAPWEED: EFFECTS OF DIET CONDITIONING. Jeffrey C. Mosley*[1], Brent L. Roeder[2], Rene Kittle[3], Jodi L. Pauley[4], Jane M. Mangold[1], Tracy K. Mosley[5], Daniel E. Lucas[6], Gerald Marks[7]; [1]Montana State University, Bozeman, MT, [2]Montana State University, Choteau, MT, [3]Montana State University, Polson, MT, [4]Montana State University, Deer Lodge, MT, [5]Montana State University, Livingston, MT, [6]Montana State University, Philipsburg, MT, [7]Montana State University, Missoula, MT

We investigated whether diet conditioning (a.k.a., diet training) would increase cattle use of spotted knapweed (*Centaurea stoebe*) and increase the efficacy of targeted cattle grazing to suppress this invasive perennial forb. We applied targeted cattle grazing for three consecutive years to spotted knapweed-infested rangeland in northwestern Montana, USA. Cattle simultaneously grazed within six, 1.3-ha pastures at a moderate stocking rate and low stock density during late July-early August (spotted knapweed in late bud-early flower phenotypic stage). Three yearling Angus heifers grazed within each pasture for 15 days in 2013 and 2014 and 12 days during the 2015 drought. Each year, three pastures were grazed by unconditioned cattle, whereas three pastures were grazed by cattle conditioned to eat spotted knapweed. Immediately preceding each year's targeted grazing trial, cattle in the conditioned treatment were systematically introduced to novel and nutritious foods (cracked corn, rolled barley, wheat bran, and others) for four days, followed by six days in which cattle were gradually introduced to spotted knapweed to encourage its consumption during the grazing trial. Otherwise, cattle in our study had no previous experience eating spotted knapweed before arrival at our study site. Our results revealed that diet conditioning did not affect any of the response variables we sampled ($P > 0.10$). Cattle diets averaged 10% spotted knapweed and 38% graminoids; forage utilization averaged 38% and 56% for spotted knapweed and perennial graminoids, respectively; neither conditioned cattle nor unconditioned cattle

preferred eating spotted knapweed (preference index = 0.45); and cattle grazing averaged 85% removal of spotted knapweed buds, flowers, and seed-heads. After three years of treatment, targeted cattle grazing reduced spotted knapweed plant density 66%, but diet conditioning provided no additional benefit.

EVALUATING PRODUCER APPLICATION OF AND CONSTRAINTS APPLYING INVASIVE PLANT MANAGEMENT STRATAGIES AND TOOLS. Theresa Becchetti*[1], Philip Brownsey[2], Maddison Easley[3], Jeremy James[3]; [1]UCCE Stanislaus County, Modesto, CA, [2]Independent Consultant, Sacramento, CA, [3]UCCE Sierra Foothill Research and Extension Center, Browns Valley, CA

While research on invasive rangeland plants such as medusahead (*Taeniatherum caput-medusae*) has been advancing for decades, adoption of practices by ranchers is limited due to logistical and financial constraints as well as uncertainty in practice outcomes since research plot level does not always translate to pasture scale. The first part of this project focused on extending research through decision support. Working with a producer, intial meetings were held to detail management practices research has indicated to be effective in Medusahead management at a pasture scale. The rancher identified practices that best fit with the ranch goals in mind and a grazing management plan was created. Five research units were created in two pastures. Species composition and medusahead cover were recorded prior to the start of the project and exclosures were created to measureforage production. Seeding a competitive species of annual grass and timed grazing management were the two practices selected by the rancher. Annual ryegrass (*Lolium multiflorum*) was selected as the species to plant for its similar phenology to medusahead and was intended as an intermediate step in the ranch goals to increase forage palatability and move towards perennial grasses in the future. Only three pastures were planted, the same pastures each year, while the other two were left status quo. All pastures had livestock turned in at the same time, and grazed to same stock density. Field days were held to extend the information and results and allow other ranchers to see practices in action on a pasture scale. Issues that impact practice effectiveness at the pasture scale include immediate concerns for feeding cattle vs long-term goals; need to move cattle to other pastures/ranches before optimal timing to control medusahead and consequently increased medusahead decreases palatable forage for fall.

CHARACTERIZING TEMPORAL ECOPHYSIOLOGY FOR CHEMICAL MANAGEMENT OF HUISACHE (*ACACIA FARNESIANA*). Pablo C. Teveni*, Robert Cox, Ron E. Sosebee; Texas Tech University, Lubbock, TX

Huisache (*Acacia farnesiana* [L.] Willd.), a pest tree species on rangelands throughout the southern third of Texas, is expanding in range and density, displacing forage grasses and forbs, and resisting control via herbicide, fire, or mechanical methods through vigorous resprouting and prolific seed production. The objectives of this research were to characterize the optimal timing and environmental conditions for effective herbicide

control. Four huisache-invaded pastures with different soil textures from four counties along the Texas Coastal Bend region were used in this study. On-site weather station data was gathered, and average phenological stage of huisache was determined each month for each pasture; shrubs from the average phenological stage were used for TNC (total nonstructural carbohydrate) analysis and herbicide treatment. Each month between April 2012 and November 2014, five shrubs per site were excavated and the root crowns were collected, frozen, dried, ground, and analyzed for TNC. In addition, two herbicide formulations were foliar-applied to five to ten shrubs every month at the four sites, and mortality was evaluated following two growing seasons. Data were analyzed using a randomized complete block design ANOVA (using study site as a blocking factor), with appropriate post hoc tests used to separate means. Root crown TNC results reveal significant increases (compared to the prior month) during May, August, and December. Increases in TNC from one month to the next result from translocation of TNC from aerial portions of the plant into the root crown; in other weedy species foliar application during downward translocation of TNC has increased mortality of treated plants. Herbicide-induced mortality was greatest during the months of October, May, November, and September.

INDAZIFLAM: A PROMISING NEW HERBICIDE FOR MANAGEMENT OF INVASIVE ANNUAL GRASSES ON RANGELANDS. Paul Meiman*, Derek Sebastian, Scott Nissen, George Beck; Colorado State University, Fort Collins, CO

Managing invasive winter annual grasses on rangeland and in other non-crop areas remains challenging. Currently, there are limited options for consistent control of winter annual grasses, and even fewer that provide multiple years of control and do not injure desirable plant communities. Imazapic has been one of the most-widely used herbicides on rangeland, but this herbicide lacks consistency beyond the year of application and can cause injury to perennial grasses. Indaziflam, a new herbicide mode of action for rangeland weed management, has provided long-term residual control of winter annual grasses. For each herbicide, seven rates were used to develop dose-response curves for 6 species of invasive annual grasses. Log-logistic regression was conducted to determine GR50 values. Indaziflam provided superior winter annual grass control across all species, compared to imazapic. The GR50 values for imazapic were on average 15 times greater than indaziflam. Four field studies were conducted to compare downy brome and feral rye control with indaziflam to currently recommended herbicides, and evaluate treatment impacts on the established co-occurring plants. Indaziflam treatments resulted in a 10 to 16-fold increase in perennial grass biomass 2 YAT and maintained downy brome and feral rye control (95-100%); while, imazapic resulted in 2 to 4-fold increase in perennial grass biomass 2 YAT, with no impact on downy brome and feral rye biomass. Indaziflam treatments showed no visual injury to the non-target perennial grasses, forbs, and shrubs. Indaziflam provided superior residual downy brome and feral rye control. The residual downy brome control achieved by a single indaziflam application could provide the opportunity to significantly reduce downy brome abundance and allow adequate time for desirable co-occurring plants to re-establish. This

research provides evidence of a new option for invasive winter annual grass control on rangelands. Studies are underway to develop a grazing label for Indaziflam.

Symposium:
Local Knowledge – Local Solutions: Science, Management and Policy

INTRODUCTION AND OVERVIEW: INTEGRATING COMMUNICATION AND CONFLICT RESOLUTION IN A DYNAMIC LANDSCAPE. Terry A. Messmer*; Utah State University, Logan, UT

The sagebrush (*Artemisia spp.*) landscape has been referred to as one of the most imperiled ecosystems on Earth. Concomitantly, the greater sage-grouse (*Centrocercus urophasianus*) has become the keystone species at the center of efforts to conserve the sagebrush ecosystem. The conservation of the sage-grouse in becoming a rallying cry for sagebrush conservation has also exacerbated concerns of the local communities that there are those who are trying to create a new vision of the west – a vision that has no place for them. This controversy has been referred to by the mass media as the "new war for the west." War is inherently violent. It is typically characterized by direct and calculated actions which are designed to destroy the enemy and their capability to make war. However, as the war for the west has escalated, the knowledge and values of local communities are being increasingly sought and acknowledged by federal and state agencies and non-governmental organizations. New relationships have merged out of the rhetoric of this war. The success of these relationships has been linked to reciprocity and transparency in information exchange, common goals, enhanced understanding of rules of law and social processes, and shared scientific discovery which collectively created a foundation for mutual trust. This social engagement processes, often referred to a local working groups, are enhancing the connectedness of communities to government and shaping individual and group action leading to increased ownership and positive outcomes. Through these processes innovation, new ideas, and risk taking are encouraged. However, even given innovative successes, there remain practical and policy challenges and unresolved questions regarding how governments view and responds to communities empowered to make their own decisions.

UTAH'S SAGE-GROUSE LOCAL WORKING GROUPS: PROCESS AND EVOLUTION OVER TIME. Lorien Belton*[1], Terry A. Messmer[1], S. Nicole Frey[2], Dave K. Dahlgren[1]; [1]Utah State University, Logan, UT, [2]Utah State University, Cedar City, UT

Sage-grouse local working groups (LWGs) in Utah have existed for over twenty years. During that time, the LWGs have evolved in a variety of ways. Starting with similar processes and roles, each group now fits a different niche in their local resource management scene. After overviewing the history of how the groups formed and developed their initial planning documents, this presentation delves into the ways that

several of these groups have changed in response to local needs, and how they currently function. We explore in detail the processes whereby agendas are set, projects develop, new information is handled, and participation is managed. In addition, the relationship between graduate students or other researchers and the LWGs will be contrasted across several different groups.

THE GUNNISON BASIN SAGE-GROUSE STRATEGIC COMMITTEE: A MODEL FOR SUCCESS? Jonathan Houck*[1], James O. Cochran[2], Greg Peterson[3]; [1]Gunnison County, Colorado, Gunnison, CO, [2]Gunnison County, Gunnison, CO, [3]Gunnison Basin Sage-grouse Strategic Committee, Gunnison, CO

Since 1995, sage-grouse (*Centrocercus* spp).conservation in the western United States has largely been the purview of voluntary local working groups comprised of federal, state and local governments, environmental groups, landowners, and interested citizens. The early success of a number of these local work groups resulted in conservation plans such as the Gunnison Sage-grouse Conservation Plan (GSGCP), which provided sage-grouse conservation guidance for the Gunnison Basin in south-central Colorado. However, because these groups often had no defined membership, it was possible to "load" an issue from a single perspective. Early attendance was good, but dwindled to the point of seeming to make the groups irrelevant. The desire for consensus often led to stalemates and lack of functionality for a group. Lack of administrative support and ability to make decisions further frustrated participants. In 2005 the Gunnison County (Colorado) Board of County Commissioners (BoCC) was approached by frustrated citizens, primarily ranchers, faced with a possible Endangered Species Act listing of the Gunnison sage-grouse and a dis-functional local work group, to "do something". To address citizen concerns, the BoCC created "The Gunnison Basin Sage-grouse Strategic Committee (Committtee)." The Committee consists of BoCC appointed representatives from the federal land management agencies, the state wildlife agency, the neighboring county, the ranching community, the environmental community, the development community, the recreation community, and the public at large. Formal operating guidelines and membership criteria were adopted and administrative staff support was provided from Gunnison County. The Committee also would operate under majority rule as opposed to consensus. The Committee has been meeting monthly since 2005. Has it been a success? Has it achieved the goals identified when it was created? These and other issues will be discussed during the formal presentation.

CONFESSIONS OF A COLLABORATOR. Robin Boies*; Stewardship Alliance of Northeastern Elko, Wells, NV

The Stewardship Alliance of Northeastern Elko (SANE) was formed in 2012. SANE was organized by representatives of eight ranches in northeastern Nevada in response to the potential listing of the greater sage-grouse (*Centrocercus urophasianus*; sage-grouse). The SANE land base encompasses over 1.7 million acres (688,000 ha). The area is

approximately 495,000 acres (200,000 ha) of private ranch land and around 1,200,000 acres (488,000 ha) of public land allotments managed by the Bureau of Land Management and U.S. Forest Service (USFS). Over fifty percent of the habitat found in the area was designated a Sagebrush Focal Area in the BLM Resource Plan and USFS Land Use Plan sage-grouse amendments. SANE includes the State and Federal land management and resource agencies and wildlife agencies with regulatory authority and management authority in the region. SANE tackled the planning and implementation of sound conservation management through the development of a Sagebrush Ecosystem Conservation Plan. SANE is a collaborative, consensus based local group that developed from the ground up. SANE addresses the social science side of the GRSG equation through the facilitated collaborative model that builds trusting relationships, the foundation of solution based resource management.

WYOMING SAGE-GROUSE WORKING GROUPS: LESSONS LEARNED . Tom Christiansen*[1], Bradley C. Fedy[2]; [1]WY Game & Fish Dept, Green River, WY, [2]University of Waterloo, Waterloo, ON

Greater sage-grouse have experienced population declines across their range and the species has been subjected to multiple reviews under the Endangered Species Act. Approximately 38 percent of the range-wide population occupies Wyoming. Greater sage-grouse is classified as a *Species of Greatest Conservation Need* in Wyoming. Since 2000, two statewide and eight local citizen-based working groups have developed conservation plans and advised state policy. The first statewide working group was formed in 2000 to develop a plan for the conservation of sage-grouse in Wyoming. This plan was formally adopted by the state in 2003. Implementation of the plan established eight local sage-grouse working groups charged with developing and facilitating implementation of local sage-grouse conservation plans. Plans were completed for all eight local planning areas in 2007 and 2008 and updated in 2014. The local working groups have implemented their plans by allocating over $6 million in legislative funding to conduct conservation projects across the state from 2005-2017. In 2007, then Wyoming governor Dave Freudenthal appointed a statewide Sage-grouse Implementation Team. This team was codified by the Wyoming legislature in 2015 and advises current governor Matt Mead on issues related to the Wyoming Greater Sage-Grouse Core Area Protection Policy. This policy, established via Executive Order, provides a statewide mechanism to reduce human disturbance in areas with large greater sage-grouse populations. Federal land management agencies have incorporated most aspects of the Core Area Policy into their land use planning decisions. Sage-Grouse have been the subject of much research since the mid-1990s in Wyoming, often with the funding support of both the local working groups and the Sage-grouse Implementation Team. Results of this research have informed local plans and the statewide Core Area Policy.

THREE CREEKS GRAZING ALLOTMENT CONSOLIDATION. Taylor Payne*[1], Troy Forrest[2]; [1]Utah Department of Agriculture, Randolph, UT, [2]Utah Department of Agriculture, Salt Lake City, UT

This presentation will discuss an innovative approach to large scale public land grazing management in northern Utah. Inspired by the ecologic and economic progress of a neighboring large private land ranch (200,000 acres) that implemented time-controlled grazing in the late 1970s, several visionary permittees and a county commission decided it was time to replicate the grazing strategy on 143,000 acres of Bureau of Land Management (BLM), US Forest Service (USFS), private, and State and Institutional Trust Lands (SITLA) lands. This unit is a combination of 10 separate allotments (5-BLM and 5-USFS) into one management unit called the Three Creeks Allotment. Three Creeks is an important area for Sage Grouse, Mule Deer, and Bonneville Cut Throat Trout, all of which have increased on the neighboring private land ranch model. We will discuss the social, economic, and ecologic barriers encountered in the complex political climate of environmentalism and public land management bureaucracy.

WOLVES AND LIVESTOCK: MITIGATION WITHIN THE FRAMEWORK OF THE BLACKFOOT CHALLENGE COLLABORATIVE PROCESS . Seth M. Wilson*; Research Associate, Missoula, MT

In landscapes where carnivores and people overlap, conflicts and human-caused mortality result. Since carnivores such as grey wolves (*Canis lupus*) can use a variety of habitats, it is arguable that population persistence is largely governed by the choices people make, their behaviors, and their land use practices. This long-term applied research and conservation effort in Western Montana's Blackfoot Valley relies on a systematic approach that involves local people and communities in research, planning, and conservation. We used an integrative, multi-method approach relying on one-on-one meetings, workshops, field tours, and group meetings to actively engage the local community in data collection, community-based monitoring, and participatory projects to mitigate livestock losses to wolves. We used intensive livestock and wolf monitoring in an attempt to reduce the frequency of encounter rates among wolves and livestock and a host of tools including permanent and temporary electric fencing and livestock carcass removal. Although we cannot claim causation from our efforts, results are encouraging. Confirmed livestock losses to wolves from 2006-2016 have been 2.3 depredations/year across nearly 50 ranches on roughly 800,000 acres. Less than three wolves per year have been removed due to these conflicts for the same period as the population increased from one confirmed pack to approximately twelve. Important lessons learned from this effort are the following: 1) develop community-supported goals; 2) focus on changing practices and behaviors not values; 3) create inclusive decision-making forums that emphasis common not special interests; 4) recognize livelihood interests; 5) provide economic incentives; 6) work across jurisdictional boundaries at the correct biological scale; and 7) cultivate the trust and support of key project partners. We discuss these lessons for mitigating livestock losses to wolves in a rural agricultural setting and the importance of

moving from an expert dependency model of conservation to one of peer education and stewardship.

COLLABORATIVE GROUPS RELATED TO SUSTAINABLE GRAZING ON PUBLIC LANDS. Michele Straube*; University of Utah, Salt Lake City, UT

I have been process designer and facilitator for three collaborative groups working on sustainable grazing issues on public lands in southern Utah. The Tushar Allotments Collaboration, focused on two large grazing allotments involving multiple permittees, reached consensus recommendations after two years of data gathering and negotiation. The working relationships continued to be constructive for several years, but have become more dynamic due to implementation challenges that arose over the long-term. The Collaborative Group on Sustainable Grazing for US Forest Service Lands in Southern Utah developed consensus agreement on grazing management principles and practices that provide for ecological sustainability, and are socially acceptable and economically viable. The La Sal Sustainability Collaboration (LSSC) is a first-of-its-kind effort to bring all public and private land managers in a specific geographic region together to develop a comprehensive approach to grazing management that maximizes private and public values, and implements the consensus recommendations of the Collaborative Group on Sustainable Grazing. The LSSC has not yet completed its negotiations, but should be finished by the February 2017. This Symposium presentation and subsequent paper will describe the successes and challenges of each group, positing some best practices and lessons learned for this type of place-based collaboration.

UTAH'S WATERSHED RESTORATION INITIATIVE: RESTORING WATERSHEDS AT A LANDSCAPE SCALE. . Alan G. Clark*[1], Tyler W. Thompson[2]; [1]Utah Department of Natural Resources, Salt Lake City, UT, [2]Utah Division of Wildlife Resources, Salt Lake City, UT

The Utah Watershed Restoration Initiative (WRI) is a partnership-based program in Utah to improve high priority watersheds throughout the state. WRI is sponsored by the Utah Partners for Conservation and Development. Now completing its 11th year of projects in Utah, the purpose of WRI is to restore and improve watershed health in priority areas across the state. The Watershed Program focuses on three ecosystem values: 1) watershed health, 2) water quality and yield, and 3) opportunities for sustainable uses of natural resources. This conservation effort enhances and protects Utah's present and future quality of life by improving water quality and yield, reducing catastrophic wildfires, restoring the structure and function of watersheds following wildfire, and increasing habitat for wildlife populations and forage for sustainable agriculture. Since 2006, partners have completed nearly 1,500 projects treating nearly 1.3 million acres.

Poster Session III

1. DIRECTIONAL ORIENTATION OF JOSHUA TREE FLOWERS. Steven D. Warren*[1], L. Scott Baggett[2], Heather Warren[3]; [1]US Forest Service, Provo, UT, [2]US Forest Service, Fort Collins, CO, [3]none, Salem, UT

Joshua tree (*Yucca brevifolia*) is a visually dominant plant of Mojave Desert. We documented unique directional orientation of its flower panicles in Joshua Tree National Natural Landmark in southwestern Utah. We first became curious after observing directional orientation of cactus flowers in the hyper-arid Atacama Desert of northern Chile. Because much of the Atacama lies south of the Tropic of Capricorn, the sun is always in the north. The flowers maximize exposure to sunlight by orienting themselves to the north. Although not a cactus, we hypothesized that the Joshua tree might utilize a similar strategy. Because the Mojave Desert lies north of the Tropic of Cancer, we hypothesized that Joshua tree flower panicles might orient themselves toward the south. We measured the orientation of all flower panicles on 50 random plants. The flower panicles grew primarily at the tips of branches that were oriented to the south. When branches with flower panicles were not oriented in a southerly direction, the flower panicles themselves tended to bend or tilt toward the south. This strategy maximized exposure to solar radiation. The strategy minimizes energetic costs of translocating photosynthates from the leaf rosettes to the flowers. Residual warmth in the flower panicles also provides a thermal reward for moth pollinators that emerges shortly after sunset. In the context of ecological restoration, when transplanting Joshua trees, one should ensure that the side of the plant that faced south in its natural setting, is also oriented to the south in its new setting.

2. EVALUATING CURRENT CONDITIONS OF RIPARIAN SYSTEMS ON GRAZING ALLOTMENTS & EXCLOSURES USING REMOTE SENSING. Timothy M. Bateman*[1], Eric D. Sant[2], Gregg E. Simonds[2]; [1]Utah State University, Logan, UT, [2]Open Range Consulting, Park City, UT

Riparian areas provide several essential resources and ecosystem services that allows continued prosperity in the western United States. Riparian systems also play a vital role in supporting domestic livestock on western rangelands. If not managed properly interactions between livestock and riparian systems can have a devastating effect. Because of the large amount of public lands that allow livestock grazing in the West, there needs to be a cost-efficient means to monitor and evaluate large portions of our riparian systems. Remote sensing can allow for a cost-effective approach in gaining a view of entire systems that could otherwise be missed from sample representations. Research using aerial imagery of the Marys River Watershed, located in Nevada, was conducted to provide a novel approach aimed at evaluating riparian systems on different land allotments and grazing strategies within a single watershed. Riparian areas were delineated and assessed on 14 land allotments using classification methods. Riparian

vegetation was then compared between allotments as well as between three grazing strategies (controlled, season long, exclosure). Results from this research were successful in showing variations of riparian systems per both individual allotments and grazing strategies. It is the goal of this research to provide an evaluation approach that would be beneficial to land managers in identifying successful strategies and developing new management ideas aimed at insuring the functionality of riparian areas and healthy mitigation with livestock.

3. USING HIGH RESOLUTION IMAGERY CLASSIFICATION AS A TRAINING DATASET FOR LANDSAT CLASSIFICATION OF WOODY COVER. Edward C. Rhodes*, Jay P. Angerer; Texas A&M AgriLife Research, Temple, TX

LANDSAT imagery is a freely available global dataset that is attractive for many remote sensing applications, however, the 30m resolution is not ideal for more detailed analyses such as estimating woody plant cover on a localized scale. In this study, we researched the feasibility of using 2m high resolution (HiRes) imagery to create a woody cover classification training dataset that would be applied to natural color (4,3,2 band) LANDSAT 8 data over a desert area in Kenya, Africa, and oak-juniper cut plains near Lampasas, Texas, USA. We began by classifying the HiRes imagery into woody and non-woody classes using Example Based Feature Extraction in ENVI 5.3. The resulting HiRes raster classification layer was Aggregated into a 30m cell size in ArcGIS 10.3 and reclassified based on percent woody cover per cell ($<$ 20%, 20-40%, 40-60%, 60-80% and >80%). A random sampling of 2,000 cells was taken from the aggregated raster. Of these 2,000 cells, 1,000 were used as an example training dataset on a LANDSAT image, while the other 1,000 were used to test the classification. Our resulting LANDSAT classifications were 49.7% and 54.7% in agreement with the HiRes classifications in Africa and Texas, respectively. Both sites had better agreement in the lowest (<20%) and highest (>80%) classifications. In Kenya, the <20% LANDSAT cover class matched the HiRes classification in 74.4% of the cells; while the >80% cover class matched in 64.4% of the cells. The Texas site matched 86.59% and 50.75% in the <20% and >80% cover classes, respectively. Our results showed very similar results in two strikingly different ecosystem types, suggesting that the methodology may be repeatable in other areas as well. Areas of very low and high woody plant cover were the most discernable in the LANDSAT imagery, while areas of moderate cover were often misclassified.

4. A COMPARISON OF TWO VEGETATION HEIGHT MEASUREMENT METHODS FOR APPLICATIONS TO SAGE GROUSE HABITAT EVALUATIONS. Sean Di Stefano*[1], Nelson Stauffer[2], Jason W. Karl[3], Sarah E. McCord[3]; [1]New Mexico State University, Las Cruces, NM, [2]USDA Jornada Experimental Range, Las Cruces, NM, [3]USDA-ARS, Las Cruces, NM

The conservation of Greater Sage-Grouse (*Centrocercus urophasianus*) habitat has become a serious management issue for U.S. federal land agencies given competing land

uses and ecological change across the American West. This drives a need for data collection in Sage-Grouse habitat to assess habitat condition in a consistent manner. The 2015 *Sage-Grouse Habitat Assessment Framework* (HAF), describes site-scale habitat suitability for Sage-grouse seasonal habitats, in part, by height of sagebrush and perennial grasses and forbs. The height method described in the HAF (average of maximum plant heights) is different from the core vegetation height method (average of maximum plant heights within a series of fixed-radius cylinders) adopted by the BLM's Assessment, Inventory, and Monitoring (AIM) program and the NRCS's National Resources Inventory.

Given the widespread implementation of the core methods, there may be benefits to using these data to complete habitat suitability assessments for Sage-Grouse. We compared the HAF and core height methods for shrubs, forbs, and grasses to evaluate if the core height method could be used to characterize Sage-Grouse habitat, using data from sites across the western U.S. where both methods were applied at each survey plot.

We found a positive correlation between herbaceous and woody heights at the plot level. Individual within-plot measurements had a weaker correlation due largely to differences in which plants were measured with each method. We observed that the core method underestimated height compared to HAF as expected based on measured plant component. Simulations of the two height methods confirmed that, although they measure different indicators, the two indicators are strongly correlated. We therefore conclude that core vegetation height data are compatible with HAF habitat suitability evaluation. Where core data are already being gathered, we recommend using the core vegetation height method to satisfy HAF habitat suitability evaluations instead of collecting additional height measurements.

5. SHORTGRASS SOIL SURFACE TEMPERATURES AFTER RANGELAND FIRE: A COMPARISON OF MEASUREMENT METHODS. Grant Tipton*, Britt Smith, Robin Verble-Pearson; Texas Tech University, Lubbock, TX

Prescribed fire is a common land management tool used in rangelands of the Great Plains. The resulting changes in vegetation leads to increased warming of soil surface temperatures on recently burned sites. This influences microhabitats for ground nesting birds, reptiles, and insects whose bodies reside close the the soil surface. We examined soil surface temperatures of unburned and burned areas from a prescribed fire on 27 July 2016 and lightning-ignited fire on 14 July 2016 in shortgrass rangeland using three methods: infrared gun, soil temperature probe, and iButton temperature data loggers. Measurements were conducted from 1500-1800 on 9 September 2016 during which no clouds were present. Maximum 2 m ambient air temperature for this day was 33.2°C and maximum solar radiation was 893 wm-2. We found a significantly higher soil surface temperature in recently burned areas using all three methods (p<0.01). Variance was highest using the infrared gun and lowest using the soil temperature probe. Each method used had unique benefits: the infrared gun was able to measure litter surface temperature

as well as soil surface of unburned areas; the soil temperature probe had the lowest variation between measurements; the iButtons were able to be deployed for long periods of time and record temperatures at defined intervals.

6. RESTORATION OF ANTHROPOGENICALLY-ALTERED SPRINGS IN THE GREAT BASIN: GIVING WATER BACK TO THE DESERT. Leah Knighton*[1], Steven Petersen[1], Gail Collins[2]; [1]Brigham Young University, Provo, UT, [2]Fish and Wildlife Service, Lakeview, OR

Since the arrival of European settlers over the last century and a half, many springs and seeps in the Great Basin have been altered to provide water for livestock. In many situations, these modifications have altered natural processes that maintain spring function such as depleting surface water flows and lowering water tables below levels needed to sustain hydrophilic plant species. The purpose of this study is to characterize the impact of springboxes on ecohydrology and assess restoration potential by testing different spring reconstruction techniques. Twenty-four springbox sites were located within the Sheldon National Wildlife Refuge, located in northwestern Nevada. Sites were divided into four groups based on flow rates. Within each group, springboxes were randomly assigned to one of six treatments; 1) capped pipes within the springbox to prevent outflow, 2) removal of the springbox and filled with sand, 3) removal of the springbox and filled with gravel, 4) outer springbox shell remains and is filled with sand, 5) outer springbox shell remains and is filled with gravel, and 6) control. Data were collected during summer 2016 which included plant community composition, flow rate, water geochemistry, and water temperature. Preliminary results suggest that flow rates vary widely between spring sites, resulting in high variability in post-treatment response and recovery. Therefore, restoration efforts may need to be tailored to each individual spring depending on landscape structure and water flow. In 2017, the same measurements will be collected allowing for pre- and post-treatment comparisons to ascertain any significant effects of the treatments. The results of this study can be used by managers to assess the potential impacts of future restoration efforts on spring ecohydrology where they have been historically impaired. Additionally, these data provide insight into impacts and potential restoration techniques for plant and water flow restoration.

7. ENERGY AND PROTEIN-BASED SUPPLEMENTS IMPROVE DECADENT SAGEBRUSH USE BY ELK. Justin R. Taylor*[1], Kari E. Veblen[2], Eric T. Thacker[2], Juan J. Villalba[2]; [1]Utah State University, Richmond, UT, [2]Utah State University, Logan, UT

In the Intermountain West, elk (*Cervus elaphus*) often occur in high numbers and in some cases over-use the best quality rangeland, potentially threatening other wildlife species such as mule deer (*Odocoileus hemionus*) and Greater Sage-grouse (*Centrocercus urophasianus*). Many shrub-dominated communities are in late succesional stages, dominated by mature even-aged shrubs with little recruitment of young plants. Elk supplementation is an attractive option for reducing competition and for rejuvenating sagebrush stands through browsing since nutrients allow ungulates to ingest a great

proportion of low-quality and secondary compound-containing woody species like sagebrush. We offered choices of high-energy (molasses) and high-protein (soybean meal) supplements presented in four feeders (2 feeders/supplement) to encourage elk to visit and forage an unproductive sagebrush stand. Elk preferred (2:1) molasses to soybean meal, and a scan sampling technique using trail cameras revealed elk consuming supplement and browsing sagebrush on 69±8.5% and 40±4.8% of the scans recorded (N=820), respectively. Sagebrush utilization was measured in a 5m wide belt transect within a distance of 100m from the feeders, and it was 75-100% at 0m from feeders, 50-75% at 40m from feeders, 25-50% at 80m from feeders, and 5-25% at 100m from feeders. In conclusion, elk supplementation is a promising strategy to rejuvenate sagebrush stands and to enhance ecosystem services in the Intermountain West.

8. SECRETIVE MARSHBIRD, PASSERINE RESPONSE TO PRESCRIBED BURNING, GRAZING, HERBICIDAL TREATMENTS IN CATTAIL-INVADED WETLANDS. Sarah L. Anderson*[1], Devan A. McGranahan[2], Anthony Hewitt[3], Stephanie Day[2], Torre J. Hovick[2]; [1]North Dakota State University, Minneapolis, MN, [2]North Dakota State University, Fargo, ND, [3]U.S. Fish and Wildlife Service, Zimmerman, MN

As an invasive aquatic plant species, hybrid cattail (*Typha x glauca*) often forms monodominant stands that alter wetland structure, function, and plant species composition. Managers seek to control this invasive species to maintain wetland species diversity, heterogeneity and ecosystem processes. Secretive marshbirds are waterbirds who are cryptic in nature, seldom vocalize and live in dense, tall emergent vegetation alongside passerine species such as the Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*), Marsh Wren (*Cistothorus palustric*), Sedge Wren(*Cistothorus platensis*) and Swamp Sparrow (*Melospiza georgiana*). The cryptic nature of secretive marshbirds makes species like the Virginia Rail (*Rallus limicola)*, Sora (*Porzana carolina*), and Pied-billed Grebe (*Podilymbus podiceps*) difficult to survey; while they are known to prefer tall, dense emergent vegetation, their relationship to cattail-dominated stands is less well-understood. Furthermore, there are few studies on secretive marshbirds and passerines following the application of fire, grazing, and herbicidal treatments to reduce cattail density, and understanding this relationship could inform management decisions about cattail control and optimization of marshbird habitat. We estimated abundance for three species of secretive marshbird using point-call surveys and four species of passerines using point-count surveys and we sampled cattail abundance and structure with terrestrial laser scanning (TLS) and clipping. We sampled 16 wetlands across eight treatments in a full-factorial design testing burning, grazing, and herbicidal treatments at Sherburne National Wildlife Refuge in central Minnesota. Species-level density estimates and community-wide ordination suggested little evidence of substantial effect of treatments on marshbirds and passerines, and we discuss species composition along gradients of vegetation structure.

9. CHANGE IN CATCHMENT RESERVOIR STOCK WATER TDS CONCENTRATIONS. Mark Petersen*[1], Jennifer Muscha[2]; [1]USDA-ARS, Miles City, MT, [2]USDA-ARS Fort Keogh, Miles City, MT

Reservoirs and dugouts are valuable as temporary or seasonal sources of stock water. They are dependent on surface runoff or seepage so may be empty or hold lower quality water when most needed in dry seasons due to evaporation and a lack of runoff. Water contact with mineral soil may add solutes to retained water while evaporation may act to concentrate solutes. Cattle standing in catchment water systems can agitate organic and inorganic matter. The objective of this study was to determine if the concentration of total dissolved solids (TDS) in catchment water systems with active cattle grazing were influenced by frequency of precipitation events characterized by month. To estimate spring/summer variation in water TDS concentrations, 2 livestock reservoirs (Flood on the eastern boundary and North 4 adjacent to the southern property line) were fitted with Troll 9500™ continuous monitoring submerged TDS sensors in June through August 2016 at the 22,257 ha USDA-ARS Fort Keogh Livestock and Range Research Laboratory near Miles City, MT.   Two sensors were placed in each reservoir. The sensors recorded a reading every 1 hr at a depth of 3 feet. Overall, 7889 records were logged. Data were analyzed as a completely randomized design testing the effect of month on TDS concentration using Proc. Mixed (SAS 2014). The concentration of TDS differed ($P < 0.01$) in each month. Total dissolved solids were 652.2 + 5.3, 851.1 + 5.1 and 1173 + 6.0 ppm for June, July and August respectively. Concentrations of TDS increased 30% from June to July, 38% from July to August and 80% from June to August. Water TDS content was elevated as the summer advanced.   Monitoring TDS content may allow for livestock to be moved when declines in productivity due to elevated TDS are expected.

10. TOWARDS A REMOTE SENSING BASED INDICATOR OF RANGELAND ECOSYSTEM RESISTANCE AND RESILIENCE. Michael J. Falkowski*[1], Beth A. Newingham[2], Brady Allred[3], Matthew O. Jones[3], David Naugle[3]; [1]Colorado State University, Fort Collins, CO, [2]USDA-ARS, Reno, NV, [3]University of Montana, Missoula, MT

Understanding ecosystem resistance and resilience to disturbance and invasive species is critical to the sustainable management of rangeland systems. In this context, resistance refers to the inherent ability of an ecosystem to resist disturbance, while resilience refers to the capacity of an ecosystem to return to its original, fully functioning state post-disturbance. Recent approaches have used biophysical properties such as soil temperature and moisture regimes to model the resistance and resilience of rangeland systems across large spatial extents. Indeed, biophysical properties interact to partially govern ecosystem resistance and resilience; however, additional characteristics such as vegetation composition and structure also have a strong impact upon how rangeland ecosystems will resist or respond to disturbance. In this study, we evaluate a remote sensing approach to map rangeland resistance and resilience across large spatial extents. Specifically, the approach leverages spatiotemporal spectral diversity indices, which are

theoretically related to compositional and structural vegetation diversity, to develop an indicator of rangeland resistance and resilience. We compare this remote sensing based index to pre- and post-disturbance vegetation measurements from a variety of field sites. Our results indicate that remote sensing of vegetation compositional and strctural diversity offers an effective and efficient means to characterize and monitor rangeland resistance and resilience across large spatial extents.

11. LAND USE EFFECTS ON STREAM TEMPERATURE ALONG A TEMPERATE RIPARIAN CORRIDOR IN WESTERN OREGON. Alberta M. Gittens*[1], Carlos Ochoa[1], Derek Godwin[2]; [1]Oregon State University, Corvallis, OR, [2]Oregon State University, Salem, OR

Land use effects on water quality parameters such as stream temperature are critical for properly managing riparian ecosystems. We are conducting intensive monitoring of multiple ecological and water quality metrics along Oak Creek in the Willamette river basin. Oak Creek originates in the Coastal mountain foothills and is a tributary to two water quality impaired waterways of Oregon, Mary's River and the Willamette River. In order to assess water quality and riparian vegetation interaction we are in the process of installing monitoring equipment in various locations along the creek and at some selected locations within its contributing watershed. Stand-alone temperature sensors have been deployed to collect data on water temperature as well as ambient temperature. In addition, we are installing soil moisture and groundwater monitoring stations to look at stream-aquifer interactions as affected by agricultural land use. Multiple weather parameters to determine crop and riparian vegetation water uptake are also being deployed. We are taking a systems-based approach to better understand multiple soil-water-vegetation relationships occurring in this at-risk riparian system at. Expected project results will help producers, landowners, and other stakeholders make better-informed decisions related to land management practices and their potential effects on water quality.

12. THE NEED FOR GRAZING FINE FUELS AFTER WET PERIODS. Sherman R. Swanson*; University of Nevada, Reno, Reno, NV

Cheatgrass (Bromus tectorum L.) is a highly flammable invasive winter annual. Mega fires create homogenous vegetation that fails to provide habitat for sage-grouse and other wildlife. Resistance and resilience of sagebrush rangelands depend on proactive fire and fuels management. Appropriate livestock grazing for fuels management was elevated by Interior Secretarial Order 3335. Variation in weather creates excess fine fuel in wet years. Many tools enable harvest of fine fuel with grazing before fire. Big fire years come after one or more very wet years. This lag time provides a window for fall grazing to consume residual fuels. Grazing during summer-winter dormancy greatly reduces risks to perennial plants needed for rangeland resistance and resilience. With strong

management, grazing can be a tool for good rather than simply a land use to be restricted for less bad. Some tools and strategies could include: Focused grazing in fuel breaks; Stockmanship; Herded sheep; Protein supplements in a line; Water hauled to troughs placed in a line; Electric fences or permanent fencing; Grazing some pastures more intensely so fires burn only other smaller areas; Growing season grazing with care for perennials by following the green up the mountain; Dormant season grazing when perennials are less vulnerable; Rotating off pastures in spring when cheatgrass becomes less palatable than green perennials. Sources of AUMs/livestock include: Using existing AUMs in targeted grazing; Temporary nonrenewable (TNR) grazing AUMs preapproved with forage production criteria; Stewardship contracting; Retaining calves after weaning; Purchasing stockers and supplementing with protein to increase energy (dry grass) consumption; Retaining cull cows until spring when prices are higher. Recent drought environmental assessments have missed the mark, planning for climate variability and including the fire problem that is more consequential than drought. Finding durable solutions requires cooperation among diverse stakeholders. Collaboration will improve decisions, relationships, communities and habitats.

13. TARGETED CATTLE GRAZING TO ENHANCE SAGE-GROUSE BROOD-REARING HABITAT. Jarrett M. Payne*[1], Jeffrey C. Mosley[1], Andrea R. Litt[1], Brent L. Roeder[2], Tracy K. Mosley[3], Lance B. McNew[1], Hayes B. Goosey[1]; [1]Montana State University, Bozeman, MT, [2]Montana State University, Choteau, MT, [3]Montana State University, Livingston, MT

Suboptimal brood-rearing habitat often limits sage-grouse (*Centrocercus urophasianus*) populations in western North America. In many mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*) brood-rearing habitats, sagebrush is too dense (> 10-25%) and limits the understory forbs and arthropods that sage-grouse prefer to eat during summer. We investigated whether protein supplementation could concentrate cattle grazing or trampling during late fall to reduce mountain big sagebrush canopy cover and increase the diversity and abundance of forbs and arthropods. We applied targeted cattle grazing within three large, contiguous pastures (about 715 ha each) in the Beaverhead Mountains of southwestern Montana. Dry cows (190-210 cows per pasture) simultaneously grazed the three pastures at a light stocking rate and low stock density for two weeks in mid-October 2015. In each pasture prior to cattle grazing, we selected one 4-ha macroplot of dense sagebrush. Next, within each macroplot we identified eight 78.5-m2 microsites where mountain big sagebrush canopy cover exceeded 30%. We placed a low-moisture block protein supplement in the center of four microsites per macroplot, whereas the remaining four microsites per macroplot comprised the untreated control. Vegetation and arthropod response was quantified in early summer 2016. Mountain big sagebrush canopy cover was 71% less in treated vs. untreated microsites (11% vs. 38% canopy cover, respectively; $P < 0.001$). Bite count observations indicated that sagebrush cover was reduced by cattle trampling rather than browsing, as sagebrush comprised < 1% of cattle diets. Forb diversity was 13% greater in treated microsites ($P = 0.094$), forb species richness was 16% greater in treated microsites ($P = 0.044$), and forb composition trended higher in treated microsites (45% of herbaceous composition in treated microsites vs.

32% in untreated microsites; $P = 0.106$). Our results indicate that protein supplementation during late fall can concentrate cattle trampling sufficiently to enhance sage-grouse brood-rearing habitat.

14. USES OF FORAGE KOCHIA TO PROTECT INTACT SAGEBRUSH ECOSYSTEMS IN OREGON. Bob Gillaspy*[1], Aaron Roth[2], Lars Santana[3]; [1]NRCS, Portland, OR, [2]NRCS, John Day, OR, [3]NRCS, Redmond, OR

Sagebrush ecosystems in Oregon are threatened by many different factors. These include annual grass invasion and wildfire. This poster explores the current literature to determine the potential for Forage Kochia to address threats from annual grass invasion and wildfire. It identifies some of the benefits and drawbacks of using Forage Kochia to protect sagebrush ecosystems in Oregon.

15. UNDERSTORY VEGETATION AND SOIL MOISTURE RESPONSE TO THINNING PIÑON-JUNIPER WOODLANDS. Yasser Almalki, Sam Fernald*; nmsu, las cruces, NM

Western portions of the United States, extending from West Texas up through southern parts of Oregon, are found to be densely populated with Piñon-Juniper (PJ) vegetation. Due to the trees' widespread occurrence and consumption of limited resources, research was conducted to evaluate the effect of a reduction of P-J on the surrounding soil and understory. This research reflects comparative data collected in relation to the understory response as well as moisture levels from six watersheds, three treated watershed areas and three untreated, situated within Santa Fe Ranch. It was discovered that a direct correlation could be made between P-J reduction and increased understory vegetation production and soil volumetric water content in the treated watersheds. Managing P-J density and cover could have positive ecological implications for wildlife and surrounding vegetation.

16. FIRE BEHAVIOR AND FIRE EFFECTS OF HABITAT MANAGEMENT BURNS IN SHINNERY OAK COMMUNITIES. Michael E. Meyers*[1], Amy Ganguli[1], Scott A. Carleton[2]; [1]New Mexico State University, Las Cruces, NM, [2]United States Geological Survey, Las Cruces, NM

Prescribed burns are frequently used to improve livestock production and wildlife habitat. However, the optimal fire prescriptions to achieve specific management objectives are often poorly understood. In eastern New Mexico, land management agencies like the Bureau of Land Management (BLM) are using spring burns to manage shinnery oak (*Quercus havardii*) communities for lesser prairie chicken habitat but lack specific information about fire behavior and associated fire effects of their prescriptions. The objective of this study is to characterize thermal properties of spring burns and their

associated fire effects in southeastern New Mexico to improve burn prescriptions for BLM habitat management objectives. We measured fire residence time, maximum temperature, and heat dosage using type K thermocouples on two burns conducted in Spring 2016. The larger of the two units, Rue Patch, had six monitoring locations (four of which burned), whereas the North Well unit had four (three of which burned). The heterogeneous nature of the burn units promoted mosaic burn patterns resulting in highly variable thermal characteristics. Of the locations that burned, the Rue Patch unit had higher mean residence time (218sec), maximum temperature (314 ˚C), and heat dosage (19,863 °C s) compared to the North Well unit, which had a mean residence time of (138sec), maximum temperature (230 ˚C), and heat dosage (12,092 °C s). We attribute these differences to higher fuel loads in the Rue Patch unit in the form of shrub biomass. Plant community and wildlife habitat response to these burns, one year post fire will be discussed. This study, in conjunction with on-going lesser prairie chicken research in this area, should provide land managers critical information for lesser prairie chicken management efforts.

17. UNMANNED AERIAL SYSTEMS IN RANGELAND ECOSYSTEMS: CURRENT USE AND FUTURE APPLICATIONS. Nicole M. Durfee*, Carlos Ochoa; Oregon State University, Corvallis, OR

Unmanned Aerial Systems (UAS) offer a flexible tool for monitoring rangeland ecosystems. UAS can be adapted for use with a number of sensors to include basic digital cameras (such as a GoPro), multispectral and hyperspectral cameras, meteorological sensors, and LiDAR. The adaptability of UAS enables the collection of a wide variety of data reflecting rangeland health, to include vegetation identification, monitoring of woody shrub encroachment, and analysis of temporal changes in landscape and hydrological processes. Grazing practices and other land use activities can be more readily analyzed through UAS, improving both the timeliness and efficiency of data collection. The versatility and operational ease of UAS allows for data collection in a wide variety of environments, offering a more flexible and less expensive option to manned aircraft in many situations. Used in conjunction with ground-based sensors, UAS provide improved vertical analysis to research by gathering data at different altitudes and angles. The availability and relatively low cost of UAS makes the platform more readily available to a wider audience, expanding the opportunities for data collection and monitoring by individual stakeholders. Currently, we are using multi-rotor UAS to assess vegetation and water features in different rangeland and dryland riparian systems. We are using a combination of data collected on-the-ground and UAS imagery to assess juniper reestablishment effects on soil and water features in sage-steppe ecosystems. Additionally, we are testing UAS imagery to assess riparian vegetation and stream conditions in various locations in Oregon. The use of low-altitude UAS can be of great advantage for enhancing the state of the science in rangeland monitoring and other natural resource applications.

18. BALANCING MANAGEMENT PRIORITIES FOR GRASSLAND AND SAGEBRUSH BIRDS IN THUNDER BASIN NATIONAL GRASSLAND. Courtney J. Duchardt*[1], Jeffrey L. Beck[1], David J. Augustine[2], Lauren Porensky[2]; [1]University of Wyoming, Laramie, WY, [2]USDA-ARS, Fort Collins, CO

Shifting management priorities have the potential to drastically alter landscapes over time. This problem is especially striking in heterogeneous, multi-use landscapes, such as the Thunder Basin National Grassland (TBNG) of northeastern Wyoming. The TBNG is situated along the ecotone between the Great Plains and sagebrush steppe, containing some of the largest remaining complexes of black-tailed prairie dog (*Cynomys ludovicianus*) colonies. This patchwork of vegetation types provides habitat for imperiled species of shortgrass, mixed-grass, and sagebrush (*Artemisia* spp.) wildlife, while remaining an important resource for the ranching and energy industries. Further, there is specific conflict between shortgrass (i.e., prairie dog) and sagebrush management, as the region is a priority area both for greater sage-grouse (*Centrocercus urophasianus*) conservation and black-footed ferret (*Mustela nigripes*) reintroduction. Because habitat requirements for wildlife associated with shortgrass and sagebrush may be mutually exclusive, we initiated a study to specifically assess change in avian community structure across colony edges into adjacent sagebrush habitat. In 2015 and 2016 we surveyed birds on transects within sagebrush habitat ("sagebrush," n=10), prairie dog colonies ("shortgrass," n=10), and across prairie dog colony edges ("edge," n=41). Over two years we observed more than 60 bird species, including 14 Wyoming Species of Greatest Conservation Need. Ordinations of community data indicated distinct bird guilds occupying shortgrass (colony), mixed-grass, and sagebrush habitats, with significant community differentiation between survey strata (PerMANOVA, p<0.01). Guilds were observed along a gradient from colony centers into adjacent sagebrush habitat. However, vegetation composition on colonies varied widely, and some interior colony edges were typified by moderate sagebrush cover. Preliminary results indicate that some prairie dog colonies can support sizeable populations of sagebrush birds. Next steps include identifying threshold tolerances of shortgrass and sagebrush birds to non-habitat, providing guidance to managers to maintain the unique biodiversity of this landscape into the future.

19. WATER QUALITY CONDITIONS ASSOCIATED WITH LIVESTOCK, RECREATION, AND RESIDENCES ON MULTIPLE-USE LANDSCAPES. Kelsey DeRose*[1], DJ Eastburn[1], David Lile[2], Leslie Roche[1], Ken Tate[1]; [1]University of California, Davis, Davis, CA, [2]University of California Division of Agriculture and Natural Resources, Susanville, CA

There continues to be great concern that microbial pollution by grazing livestock degrades water quality on multiple-use rangelands, threatening human and ecological health. Given the importance of clean water on these shared landscapes, there has been growing stakeholder interest in additional water quality research across a wide range of common resource use activities at a high sampling frequency. During the 2016 summer grazing-recreation season, we conducted a cross-sectional survey of microbial water

quality conditions associated with livestock grazing, recreation, and residential use on three multiple-use watersheds in the central Sierra Nevada and southern Cascade ranges of California. These watersheds include federal public grazing lands, private irrigated pasturelands, public recreation sites, and residential areas. Our specific study objectives were to 1) quantify fecal indicator bacteria (FIB; fecal coliform and *E. coli*) concentrations in surface waters; 2) compare results to water quality regulatory benchmarks, and 3) examine relationships between water quality, environmental conditions, and primary land use. The relative percentage of FIB regulatory benchmark exceedances widely varied under individual regional and national water quality standards. Relative to USEPA's national *E. coli* FIB benchmarks – the most contemporary and relevant standards for this study – 80% of the 706 samples collected were below the recommended criteria value of 100 cfu/100 mL. FIB concentrations were significantly greater when water was turbid and when cattle were actively observed at sampling. Recreation sites had the lowest mean FIB concentrations, followed by grazing and residential sites, respectively. Our results suggest livestock grazing, recreation, and provisioning of clean water can be compatible goals across these multiple-use landscapes.

20. NATURAL RECRUITMENT OF WYOMING BIG SAGEBRUSH RELATIVE TO BURNED AREAS DURING AN EL NINO YEAR. April Smith*[1], Camie M. Dencker[2], Beth A. Newingham[3]; [1]USDA ARS GBRRU, Reno, NV, [2]University of Nevada, Reno / USDA ARS Reno, Reno, NV, [3]USDA-ARS, Reno, NV

Wyoming big sagebrush is known to have episodic recruitment, but the driving factors for these recruitment events is poorly understood. Sagebrush is not fire adapted, is a mid to late seral species, and can take multiple decades to reach a similar density of unburned stands. Fire and climate regimes, which also influence these sagebrush plant communities, have greatly changed in the last century. Understanding when and where natural recruitment of sagebrush occurs may shed light on restoration efforts. We assessed recruitment of Wyoming big sagebrush inside and outside of burned areas in western Nevada. For the fall 2015 cohort of seedlings, canopy gap, shrub richness, shrub size class, plant and ground cover, distance to nearest adult sagebrush, and sagebrush juvenile density were measured in summer 2016. In addition, 10 juveniles per plot were tracked for growth and survivorship. At the end of the first year, past fire occurrence was the strongest indicator of juvenile density, with 99% of this year's cohort located within unburned sagebrush stands. Shrub size class for non-sagebrush shrubs and distance to road were negatively associated with sagebrush juvenile density, while total plant richness was positively associated with juvenile density. Sagebrush size class and distance to adults were positively associated with juvenile growth, while gravel cover was negatively associated with juvenile growth. Seedlings will be followed for multiple years to assess growth and survival in relation to these biotic and abiotic variables, as well as climate and soil chemistry. Our results will provide insight into the episodic nature of Wyoming sagebrush recruitment and may assist managers in determining future vegetation management.

21. IMPORTANCE OF SHRUB RESTORATION ON GREAT BASIN RANGELANDS.

Charlie D. Clements*[1], Mark Freese[2], Mike Scott[3], Jeff White[4], Dan Harmon[1]; [1]USDA-ARS, Reno, NV, [2]Nevada Dept Wildlife, Reno, NE, [3]Nevada Dept Wildlife, Reno, NV, [4]Newmont Mining, Elko, NV

The recognition of brush species and the browse these plants provide as an important component of rangeland production was often overlooked in land management for some time. Even after the birth of range management in the early twentieth century, herbaceous species were considered the basic component of rangeland forage. Arthur Sampson, one of the founders of scientific range management, was among the first to describe and discuss native range shrubs as components of the basic forage supply on ranges in 1924. By 1931, USDA, Forest Service Ecologist William A. Dayton published *Important Western Browse Plants*. Dayton was in charge of the range forage investigation for the USDA, Forest Service when the agency published the *Range Plant Handbook* in 1937. By the 1940s, there was a growing concern over the use of range plants by domestic livestock and its effect on wildlife habitats, especially that for deer. In 1945, Utah State researchers L. A. Stoddart and D. I. Rasmussen entered the wildlife/livestock conflict debate with the publication *Deer Management and Livestock* where they shared the view that deer and domestic livestock could co-exist on the same rangelands. The debate over the influences of domestic livestock grazing on wildlife habitats is perhaps as robust and controversial as ever in the history of range management as many grazing permit renewals are challenged in court directly due to possible impacts to wildlife species such as sage grouse, mule deer, pygmy rabbits, and an array of other species. Here, we focus on two shrub species, antelope bitterbrush and big sagebrush to shed some light as to better understand methods by which to restore these critical shrub species in Great Basin plant communities.

22. STOCHASTIC MODELLING APPLIED TO FORAGE PRODUCTION IN SEMIARID RANGELANDS.

Magno J. Cândido*[1], Rodrigo G. Silva[2], José Lopes Viana Neto[3], Cleber M. Barreto[2], Ana Clara R. Cavalcante[4], Ronaldo O. Beserra[2], Josione M. Fonseca[2]; [1]UFC, Fortaleza, Brazil, [2]IFCE, Limoeiro do Norte, Brazil, [3]IFCE, Crato, Brazil, [4]Embrapa, SOBRAL, Brazil

The semiarid rangelands production shows a randomized pattern, following rainfall, characterizing high risk of low biomass production and high variation coefficient (43,2%) of this production. To minimize this oscillatory pattern of primary production as well as the secondary production, the nopal cactus with its CAM metabolism and its high water use efficiency should be used. So, to simulate the rainfall variability and its effect on nopal cactus, a greenhouse study was carried out in the semiarid region of Northeast Brazil. After the establishment of a mathematic relation between rainfall and biomass, using historical data of the region, the response pattern of nopal cactus along 39 years

were compared to the response pattern of the rangeland. After estimating the forage biomass of nopal cactus and rangeland, the Monte Carlo approach was applied, estimating the risk of biomass production below 1.0 Mg ha-1 ano-1, its maximum and minimum values, as well as the associated variation coefficients. The nopal cactus and rangeland estimated biomass production averaged 17147±3869 and 4352±1841kg/ha x year, with minimum and maximum values from 8663 to 23888 and from 0 to 6170kg/ha x year and a variation coefficient of 22.7 and 42.3%, respectively. The results showed that the minimum value (8663 kg) to nopal cactus is twice of the rangeland estimated biomass (4.352 kg), ameliorating he negative effects of low rainfall years. The biomass production variation coefficient was reduced from 42.3 to 22.7% by using nopal cactus as a complementary resource, enhancing the resilience of the production system. As a consequence, the feed availability, the animal production and the revenue were regularized, making the animal production in semiarid areas more sustainable.

23. GEOMORPHOLOGICAL CHANGE ANALYSIS OF EPHEMERAL RANGELAND STREAMS IN THE ALTAR VALLEY, ARIZONA: 2011-2016.
Hennessy F. Miller*, Jeffrey S. Fehmi, Hannah L. Farrell; University of Arizona, Tucson, AZ

Ephemeral streams are a key component of nutrient transport, hydrologic function, and ecological productivity in southwestern rangelands. Though geomorphic change is integral to watershed evolution, significant erosion or sediment deposition can be both an indication of and precursor to poor watershed health and upland vegetation degradation. This study had two primary objectives: (1) identification and quantification of geomorphologic changes of ephemeral stream reaches in the Altar Valley, a 610,000 acre rangeland southwest of Tucson, Arizona, between 2011 and 2016 and (2) assessment of the geomorphological impacts on ephemeral reaches following the construction of a natural gas pipeline in 2014. Using multi-temporal LIDAR data, the Automated Geospatial Watershed Assessment (AGWA) GIS tool, and ground-truthing, the study assessed the four main criteria impacting erosion rates in rangelands: climatic events, upland vegetation, soil characteristics, and slope. The experiment design included weekly or bi-weekly cross section measurements upstream, downstream, and across the pipeline right-of-way of ten study washes of varying size, upland vegetation cover, and channel bed material. Preliminary results of the disturbance study suggest increased sediment deposition downstream of the pipeline right-of-way when compared to the control upstream cross-sections. Variability in geomorphic response was linked to upland vegetation, channel bed material, and individual ephemeral stream treatments.   Identification of stream reaches with significant geomorphic changes and their contributing upland areas can be used as a tool to inform land managers on locations of priority management.

24. FORAGING RESOURCE SELECTION BY RANGELAND BATS. Rebecca Trubitt*, Torre J. Hovick, Erin Gillam; North Dakota State University, Fargo, ND

Insectivorous bats are highly important ecosystem service providers that are increasingly threatened by factors such as land use change, climate change and disease. Despite their ecological importance, relatively little is known about the distribution and resource needs of bats in the Great Plains. Our objective was to inventory bats in the northern Great Plains using acoustic survey methods, and model the influence of landscape variables on resource use. We deployed Pettersson d500x ultrasonic bat detectors at 244 sites randomly selected from a 1 km point grid covering the study area for a total of 854 detector-nights. We identified the collected calls using Sonobat autoclassification software and accepted classifications made with at least 95% confidence. We recorded 5,514 calls that met our inclusion criterion from four bat species: big brown bats (*Eptesicus fuscus*), eastern red bats (*Lasiurus borealis*), silver haired bats (*Lasionycteris noctivagans*) and hoary bats (*Lasiurus cinereus*), and we confirmed the presence of these species with mist netting. The most commonly recorded bat was *L. noctivagans* (78% of sites), followed by *L. cinereus* (61% of sites), *E. fuscus* (52% of sites) and *L. borealis* (9% of sites). Future analyses will model the responses of these species to landscape variables including the amount of open water, trees, row crops and open grassland in the surrounding landscape, the distance to trees, water or human-built structures, and road density. This study has added greatly to our understanding of the distribution and resource use of bats in the northern Great Plains and will guide future conservation planning for these species.

25. MULTI-SCALE ASSESSMENT OF FACTORS AFFECTING SECRETIVE MARSHBIRD ABUNDANCE IN NORTH DAKOTA. Joseph Orr*[1], Torre J. Hovick[1], Benjamin Geaumont[2], Craig Marshall[1]; [1]North Dakota State University, Fargo, ND, [2]North Dakota State University, Hettinger, ND

Over the last two centuries >50% of North American wetlands have been drained for agricultural production. As a result, wetland dependent wildlife are of high conservation concern and threats to these ecosystems are widespread and pervasive. Of particular importance is the prairie pothole region (PPR) of North America that produces 50%-80% of the continents waterfowl and also provides habitat for >100 other wetland-dependent birds. Despite the importance of the PPR for biodiversity conservation, few studies have estimated densities for secretive marshbirds in this region or investigated factors driving wetland selection. We used the North American Marshbird Monitoring Program sampling protocols to investigate habitat selection and abundance of nine secretive marshbirds across multiple scales in the PPR. We detected 327 individuals comprised of seven of our nine focal species. The most abundant species was Virginia rail (*Rallus limicola*) with 2.5 ± 0.7 birds-ha, followed by pied-billed grebe (*Podilymbus podiceps*) 0.7 ± 0.1 birds-ha, American bittern (*Botaurus lentiginosis*) 2.1 ± 1.7 birds-ha, and sora (*Porzana carolina*) 2.1 ± 0.9 birds-ha. This preliminary data suggests that the PPR region is of great importance to secretive marshbirds as these densities are much higher than other areas reported in the Midwest and Great Plains. This information coupled with

future analyses on landscape variables influencing habitat selection will greatly improve our general knowledge and ability to plan conservation for secretive marshbirds in the northern Great Plains.

26. IMPACTS OF ENCROACHING WOODY VEGETATION ON GRASSLAND BREEDING BIRD COMMUNITY STRUCTURE AND ABUNDANCE. Craig Marshall*[1], Torre J. Hovick[1], Benjamin Geaumont[2], Scott Kronberg[3]; [1]North Dakota State University, Fargo, ND, [2]North Dakota State University, Hettinger, ND, [3]USDA-ARS, Mandan, ND

Contiguous grasslands of North America have been converted into a mosaic of forested areas, agricultural crops, urban development, and isolated grassland tracts. Remaining grassland tracts have been stressed or degraded due to the loss or mismanagement of disturbance regimes. Alterations to disturbance regimes creates homogeneous grassland plant communities and allows for the establishment of woody vegetation. Encroachment of woody vegetation may functionally alter grassland-associated communities and displace grassland dependent wildlife. We evaluated the breeding bird community using line transect surveys within nine grazed mixed-grass prairie landscapes. We used non-metric multidimensional scaling to assess breeding bird community level changes to the presence of woody vegetation and used unmarked in program R to determine individual species responses to the encroachment of woody vegetation. We detected 517 individuals of 32 different breeding bird species during the summer of 2016. Community level analysis revealed a shift in the breeding bird community from a grassland dominated bird assemblage towards a woody tolerant grassland and shrub-dominated assemblage as woody vegetation coverage increased. Species level analyses revealed a decline in abundance of two obligate grassland species (Grasshopper Sparrow [*Ammodramus savannarum*] and Bobolink [*Dolichonyx oryzivorus*]) as woody coverage increased, whereas, an increase in abundance was determined for one facultative grassland species (Clay-colored Sparrow [*Spizella pallida*]) as woody coverage increased. In order to conserve grassland bird populations, disturbance regimes and mechanical means must be restored and properly applied to grassland systems in order to remove and control the encroachment of woody vegetation.

27. MULTI-SCALE ANALYSIS OF GRASSLAND BIRD ASSOCIATIONS ON A WORKING LANDSCAPE. Brian J. Chepulis[1], Lawrence D. Igl[2], Edward S. DeKeyser*[1]; [1]North Dakota State University, Fargo, ND, [2]Northern Prairie Wildlife Research Center, Jamestown, ND

The spatial arrangement and functioning of natural ecosystems worldwide are rapidly changing as humans continue to convert these areas for residential, commercial, and agricultural development. As the global human population continues to rise, landscape degradation and fragmentation will continue to be major drivers of biodiversity and thus,

ecosystem stability. Of all the threats to natural ecosystems, the industrialization of rangelands is of particular concern due to their global vastness, high levels of biodiversity, and large economic and social benefits. In the northern Great Plains, many rangeland-dependent species are imperiled due to an unusually high rate of grassland conversion. For example, since 1966, 24 grassland obligate breeding birds have declined by nearly 40%. Our overall objective was to determine the landscape and site-specific factors influencing the presence and abundance of grassland birds on the Little Missouri National Grassland (LMNG) in western North Dakota.

Since livestock grazing remains an important social and economic activity on the LMNG, it is essential to further understand the effects of grazing on breeding populations of grassland birds. The recent boom in energy development in the Bakken region of North Dakota also gave us the unique opportunity to assess the effects oil development on a suite of grassland bird species. We surveyed breeding bird populations over two years (2014-2015) on sixty quarter-sections in the LMNG. We also measured several multi-scale metrics that are believed to influence breeding grassland bird abundance (e.g., vegetation structure). Our results further highlight the importance of providing a landscape mosaic for different species of grassland birds. We hope that land managers can use the information from this study to identify specific mechanisms by which conservation measures for declining grassland birds can be improved.

28. EFFECTS OF SOIL TYPE AND PRECIPITATION ON SEEDLING DEMOGRAPHY OF THE NATIVE GRASS, *ELYMUS ELYMOIDES*. Jesse R. Morris*[1], Steven Petersen[2], Matthew Madsen[2]; [1]Brigham Young University, Orem, UT, [2]Brigham Young University, Provo, UT

Elymus elymoides (bottlebrush squirreltail) is a native perennial grass species commonly included in seed mixes for rangeland revegetation. Within western landscapes characterized by low precipitation and warm temperatures, the establishment of native species is often marginal at best. Limitations to germination and seedling establishment have been identified as "bottlenecks" to plant establishment. The purpose of this study is to characterize seedling demography for *E. elymoides*, including germination, timing of seedling emergence, and growth rates in contrasting weather and soil conditions. We simulated the timing and volume of precipitation events for both a wet and dry year on the Utah Test and Training Range (UTTR), located in the western Utah cold desert. These simulated precipitation regimes were compared with a daily watering treatment, and all watering treatments were tested in both native soil from the UTTR and commercially available potting soil. We tested percent germination and recorded timing of seedling emergence as well as seedling density. We measured plant height daily for 75 days to track growth rates. We hypothesize that soil moisture is the most limiting factor to germination, emergence, and growth rates. Native soils will likely be a limiting factor to emergence and growth rates due to lower nutrient content and crusting of the soil surface. Preliminary results will be presented at the conference. Knowing how differing weather and soil conditions affect the establishment of native species will aid land managers in establishing revegetation protocols that account for variations in soils and projected weather conditions.

29. APPLICATION OF WEB-BASED CLIMATE INFORMATION TOOLS FOR THE EDWARDS PLATEAU REGION OF TEXAS. Douglas R. Tolleson*[1], Mike Crimmins[2], John W. Walker[3], Robert Moen[1], Nick Garza[1], Charles Taylor[1]; [1]Texas A&M University, Sonora, TX, [2]The University of Arizona, Tucson, AZ, [3]Texas A&M AgriLife Research, San Angelo, TX

Climate extremes are a recurring natural phenomenon in the southwestern US. Records kept since 1919 at Texas A&M Agrilife Sonora Research Station (SRS) indicate that approximately 18% of years experienced precipitation < 75% of the long-term average (571 mm), while approximately 17% of years received > 125%. Contingency planning helps rangeland managers prepare for climatic extremes. Web-based tools have been developed to capture long-term weather data and make it available to rangeland managers. The objectives of this study were to: 1) evaluate the relationship between SRS-observed and Parameter-elevation Relationships on Independent Slopes Model (PRISM)-interpolated precipitation, and 2) introduce and apply web-based climate information tools for rangeland managers in the region. Using the University of Arizona's Standardized Precipitation Index (SPI) Explorer tool georeferenced to the study location, annual (1919 – 2015) and monthly (2000 – 2015) PRISM precipitation and SPI values were calculated. The relationship between SRS and PRISM precipitation was determined using simple linear regression. Differences in mean 12 or 3-month SPI per decade were determined using analysis of variance procedures. Significant ($P < 0.01$) positive correlations were obtained for annual ($r2 = 0.77$, slope = 0.84, SE = 3.1) and monthly ($r2 = 0.75$, slope = 0.83, SE = 1.83) SRS versus PRISM precipitation. Numerical extremes ($P > 0.1$) in decadal 12-month SPI were the 1950's (- 0.89 ± 0.49) and the 1970's (0.30 ± 0.23). Numerical extremes ($P > 0.1$) in decadal April-May-June SPI were the 1960's (-0.31 ± 0.38) and the 1940's (0.39 ± 0.28). PRISM interpolations of precipitation for the western Edwards Plateau region were of sufficient accuracy to be usable in retrospective analyses, but could be improved with inclusion of SRS data. 12 and 3-month SPI values can be used as one source of climatic information in proactive rangeland planning.

30. A LITERATURE REVIEW: WOLF DEPREDATION ON LIVESTOCK AND ELK. Amber Dalke*, George Ruyle; University of Arizona, Tucson, AZ

Wolf reintroduction in the lower 48 states is a contentious issue. Many strategies are in place to both compensate ranchers for livestock loses due to wolves and to reduce the negative interactions among the species. The aim of this literature review is to gain insight into the full spectrum of effects of wolf depredation on domestic livestock and elk, and to examine management strategies used to reduce wolf depredation on livestock. In order to further understand this complex relationship, literature was reviewed from peer reviewed journals, government agency documentation, and book chapters from the United States and Europe. Many studies from the United States exist regarding wolf introductions in the west (northern gray wolf in and around Yellowstone

and the Mexican gray wolf in the southwest). There are also a large number of studies from Europe where wolves and livestock/game species ranges have overlapped over a longer period of time compared to the U.S. studies. Preliminary findings suggest that there are direct and indirect effects of wolf depredations on livestock and game populations. Direct effects of wolves include loss of livestock/game and physical harm to animals, while indirect effects include weight loss, diet and habitat selection changes, and altered social group responses. Management strategies used to reduce wolf impacts on livestock/elk include telemetry collars on wolves (which allow ranchers to relocate livestock during sensitive times of the year, such as calving), herding dogs, temporary fencing and other impediments. Ranchers also have changed calving seasons and employed riders. Understanding the effects of wolf depredation on livestock and elk, and the effectiveness of the various mitigation efforts will help inform land managers about the most appropriate ways to limit the harmful effects of coexistence.

31. WATERSHED ASSESSMENT: EVALUATING THE RELATIONSHIP BETWEEN RANGELAND HEALTH AND INTERMITTENT STREAM STABILITY. Garret A. Hecker*[1], Miranda A. Meehan[1], Jack Norland[1], Jeffrey L. Printz[2]; [1]North Dakota State University, Fargo, ND, [2]USDA-NRCS (Retired), Lisbon, ND

It is widely recognized that riparian health is inherently linked to watershed condition and the health of the adjacent ecological sites. Land management has the potential to impact riparian stability as different uses may alter the ecological function of ecological sites. To determine the relationship between the health of upland ecological sites and stream stability (stream type and risk of streambank erosion), thirty-five reaches across five watersheds were sampled in Bowman County, ND. The major land use in the study area is grassland as livestock production is the primary use. The stream types were classified using Rosgen's Stream classification of natural rivers which separates stream channels based on their dimensions. The Bank Erosion Hazard Index (BEHI) was used to determine how at risk the streambanks were to erosion. The 17 Indicators of Rangeland Health (IRH) protocol was used to assess the ecological sites associated with each reach. IRH evaluates the ecological function of an ecological site by using 17 indicators to measure departure of soil and site stability, hydrologic function, and biotic integrity from the reference state. A Nonmetric Multidimensional Scaling ordination was performed to analyze the data. Analysis indicated that IRH indicators related to soil & site stability and biotic integrity attributes had the greatest influence on stream stability. Streams with greater instability and high risk of erosion, F and G stream and those with a high BEHI ratings, were correlated with soils with increased compaction and decreased aggregate stability. Reaches with greater stability, E and C streams with low BEHI ratings, were associated with increased amounts of litter and properly functioning soils. Based on these findings IRH can be useful tool to determine if a stream reach is at risk of transiting to an unstable state.

32. PASSERINE AND INSECT COMMUNITIES ALONG DUST DEPOSITION GRADIENTS IN BAKKEN OIL PATCH. Jonathan W. Spiess*[1], Brittany N. Poling[1],

Devan A. McGranahan[1], Craig W. Whippo[2], Torre J. Hovick[1], Aaron Daigh[1]; [1]North Dakota State University, Fargo, ND, [2]Dickinson State University, Dickinson, ND

Energy development has increased over the last decade in North Dakota with the use of hydraulic fracturing and horizontal drilling altering the amount and type of traffic on unpaved roads throughout the largely rural Bakken region of the state. Previous research on traffic and dust deposition effects has primarily focused on plant performance, which overlooks potential effects on bird and insect communities within impacted agro-ecosystems. Prompted by increased signs of bird activity in dust collectors further from unpaved roads, we hypothesized that birds either (1) respond directly to traffic and/or dust deposition or (2) respond indirectly to differences in prey abundance along dust deposition gradients. We installed trail cameras to observe bird activity and used sweep nets to sample potential insect prey communities along transects used to monitor dust deposition at increasing distances from unpaved roads. Our objectives were to determine: (1) the species, relative abundance, and behavior of birds perched and using the dust collectors; and (2) the abundance and coarse taxonomic classification of insects. We compare bird and insect abundances with dust deposition rates at their collected distances. Habitat fragmentation and landscape industrialization are concerns for rural areas undergoing energy development, and attention to the less-obvious effects of increased traffic and dust deposition can help landscape and civil planners mitigate environmental impacts.

33. RANGE GRASSES, CROPS OF THE BAKKEN APPEAR RESISTANT TO EXTREME LEVELS OF FUGITIVE ROAD DUST. Brittany N. Poling*[1], Jonathan Spiess[1], Jenny Foggia[2], Devan A. McGranahan[1]; [1]North Dakota State University, Fargo, ND, [2]Nebraska Cooperative Fish and Wildlife Research Unit, Lincoln, NE

New technologies, such as hydraulic fracturing, have increased energy development in the Bakken region of North Dakota. But the hydraulic fracturing process requires massive amounts of water input and disposal, which has in turn increased truck traffic on rural, unpaved roads. This traffic generates fugitive dust, which often settles on adjacent rangelands and crop fields. Currently, there is little research on the effect of fugitive dust on plants. Potential impacts include altered leaf-level physiology such as photosynthesis, respiration, productivity, and transpiration rates. Because precipitation increases spatial and temporal variability in foliar dust load, field studies can be complicated, so we conducted a greenhouse study to simulate the conditions of dust deposition in the Bakken region. We focused on native and exotic perennial rangeland grasses and annual crops of economic importance to the Northern Great Plains. To simulate actual and extreme foliar dust exposure in the Bakken, we applied 40 g/m^2 of scoria road dust—approximately that accumulated after 1 mo of truck traffic—at thrice-weekly intervals, for total dust exposures of 280 g/m^2 in perennial grasses and 200 g/m^2 in crops per round. Prior to dust application, perennial grasses had been established in 8-in pots for > 9 mo and crops had reached the 5-leaf stage. Measurements for perennial grasses included dry weight of post-clipping biomass recovery following two rounds of dust exposure. Measurements for crops included stomatal conductance, photosynthetic efficiency, chlorophyll content,

leaf area and specific leaf area. We found no evidence of extreme foliar dust on post-clipping recovery of perennial grasses, and discuss impacts of extreme foliar dust on adolescent crops. Overall, our results suggest increased dust deposition due to energy development likely has little impact on the performance of rangeland grasses and crops in the Bakken region.

34. UTILIZATION OF WET BREWERS GRAIN AS A WINTER FEED SUPPLMENT FOR BEEF COWS GRAZING NATIVE ANNUAL GRASSLANDS. Grace E. Woodmansee*[1], Kaylee N. Bohn[2], S. Patrick Doyle[2], David A. Daley[2], Josh S. Davy[3], Dustin Flavell[4], Nikolai Schweitzer[4], Kasey L. DeAtley[2]; [1]University of California, Davis, Davis, CA, [2]California State University, Chico, Chico, CA, [3]University of CA, Red Bluff, CA, [4]University of California, Browns Valley, CA

Objectives of this study were to determine the effects of wet brewers grain (WBG) as a winter supplement on cow and calf performance while grazing native annual grasslands. The study was conducted at the Sierra Foothill Research and Extension Center (Browns Valley, CA) during 2014-2015 and 2015-2016 winter grazing seasons (i.e., November-January). A total of 92, fall-calving Angus x Hereford cows grazing native annual pastures (12.12 ha/pair for 84 d; 3.56% CP, 39.3% TDN, 75.3% NDF) were supplemented with either molasses low moisture protein block, available ad libitum (CON; n = 28; CP: 26%) or WBG (fed 3 times/wk; formulated to offer 0.68 kg CP head/d on DM basis; CP: 26%). Treatment groups were housed in adjacent pastures during the 84 d supplementation period and weights were taken in 28 d intervals. Dependent variables included: cow and calf BW and cow BCS. Data were analyzed as a randomized block design where block = year of study. Treatment x block interaction was not significant ($P > 0.05$). Calves were born prior to beginning of study each year and calf date of birth was fit as a covariate. Brewers grain supplemented cows were heavier on d 56 compared to CON cows (560.63 vs. 529.86 ± 13.99 kg; $P = 0.03$). Similarly, WBG calves were also heavier on d 56 compared to CON calves (117.97 vs. 110.06 ± 3.72 kg; $P = 0.03$). Calves born to WBG supplemented cows tended ($P < 0.10$) to be heavier than those of CON supplemented cows on d 0 (57.96 vs. 58.81 ± 2.73 kg) and d 86 (141.64 vs. 152.03 ± 3.74 kg). Results indicate that cows and calves supplemented with WBG recovered weight more quickly than those consuming liquid protein supplement. Therefore, WBG may have considerable potential as a winter protein supplement on California grasslands; however, economic analyses need further investigation.

Poster Session II

1. GLYPHOSATE APPLICATION AND CATTLE GRAZING: AN INTEGRATED APPROACH TO CONTROL MEDUSAHEAD. Casey Spackman*[1], Kip Panter[2], Clinton

Stonecipher[2], Juan J. Villalba[1]; [1]Utah State University, Logan, UT, [2]USDA-ARS, Logan, UT

Livestock avoid grazing the invasive annual grass medusahead (*Taeniantherum caput-medusae* (L.) Nevski). We hypothesized that application of the herbicide glyphosate to medusahead stands would increase use of the weed by livestock. Six medusahead-infested plots (0.054 ha each) were divided into three 6 m by 30 m strips and randomly assigned to the following treatments: 1) application of glyphosate (RT 3; Roundup brand) at a rate of 394g ae ha-1, 2) potassium chloride (KCl; salt in RT 3) at a rate of 174g ai ha-1, and 3) Control (CTRL, no chemical application). Seven days after treatment, beef steers (n=12) were randomly paired and assigned to each of the 6 plots in a complete randomized design with repeated measures. Animals were allowed to graze from 0800 to 1700 from June 11 to June 18, 2016. Foraging events on medusahead (MH), other grasses (GR) and forbs (F) were measured using the bite count technique at successive five minute intervals per steer for 4 h/d. Cattle preferred on average GR (11.5 ± 0.4 bites/min) over F and MH (2.7 ± 0.2 and 2.7 ± 0.6 bites/min, respectively). However, bite counts in RT 3 steadily increased for GR, MH, and F from June 14 (3.3 ± 0.3; 0.3 ± 0.3; 0.7 ± 0.1 bites/min) to June 18 (4.5 ± 0.3; 2.5 ± 0.3; 1.1 ± 0.1 bites/min, respectively), while bite counts for GR, MH, and F in KCl and CTRL increased to a lower extent during the same period. Moreover, the proportion of medusahead removed from RT 3 strips increased steadily from June 12 to June 18 (from 0.02 to 0.5 ± 0.09), a much greater increment than for KCl (from -0.08 to 0.01 ± 0.02) or CTRL strips (from -0.06 to 0.06 ± 0.03). The greater utilization of glyphosate-treated medusahead plants and strips suggests that an integrated approach of herbicide and grazing treatments is an efficient tool to control medusahead spread in rangelands.

2. SOCIO-ECOLOGY AND TYPOLOGY OF DICHOTOMOUS GROUPS IN WYOMING, USA WITH IMPLICATIONS FOR AGRICULTURE AND CONSERVATION. John D. Scasta*; University of Wyoming, Laramie, WY

Rangelands and forest lands of the western United States have become increasingly valued and criticized for the provision of ecosystem services, biodiversity, and livestock agriculture. These conflicts are particularly acute in Wyoming, USA where half of the state is federally owned, the surface ownership pattern is heterogeneous, and conservation and agriculture are substantial. We surveyed Wyoming-based members of seven agricultural (Ag) and seven environmental/conservation (Env/Con) stakeholder groups to: (1) determine if special interests were mutually exclusive, (2) identify perceptions of compatibility of agriculture and conservation, (3) quantify ranking of 10 values for open spaces, and (4) determine commonalities between groups. A total of 197 participants completed the survey; 150 from Ag groups and 47 from Env/Con groups. Two Env/Con groups declined to participate altogether. Interests were not mutually exclusive because 63% of Ag participants also indicated an interest in natural resources and 55% of Env/Con participants indicated an interest in agriculture. Groups agreed that Wyoming's open spaces are important for both the conservation of biodiversity and livestock grazing. However, 94% of Ag participants reported that

biodiversity conservation and livestock grazing are compatible, compared to only 70% of Env/Con participants. Values such as 'meat production' were ranked first by Ag participants but next to last by Env/Con participants. However, 'watershed', 'plant diversity', and 'wildlife diversity' were both ranked in the top five for both groups, an indication of common ecological values. Both groups indicated that maintaining open space and functioning ecosystems, or preventing fragmentation, was the greatest commonality. Groups also suggested additional communication, respect, and research are needed to achieve harmony. Our results indicate the rhetoric of division between agriculture and environmental/conservation groups does not represent reality. Both types of groups have a unifying 'ecological heritage' that can lead to accomplishing compatible objectives such as maintaining open space through traditional pastoralism.

3. EFFECTS OF INCREASED SOIL NITROGEN ON THE GROWTH AND COMPETITION BETWEEN NATIVE AND INVASIVE GRASSES. Megan J. Endreson*, Ryan F. Limb; North Dakota State University, Fargo, ND

Rangeland management is currently challenged by the emergence of novel ecosystems, many of which developed with the invasion of exotic species. Kentucky bluegrass (*Poa pratensis*) and yellow sweet clover (*Melilotus officinalis*) are exotic invaders currently degrading native rangelands by altering ecosystem processes and reducing plant diversity. Understanding the mechanisms behind Kentucky bluegrass establishment and its interactions with other species will advance current strategies to control its invasion. Therefore, we determined how increased soil nitrogen from exotic yellow sweet clover impacts both the growth of and competition between native western wheatgrass (*Pascopyrum smithii*) and invasive Kentucky bluegrass. In a controlled greenhouse environment, we grew *Melilotus* in pots and killed each plant by clipping at the soil surface after eight weeks of growth. We transplanted three different *Poa* and *Pascopyrum* seedling combinations into pots both with and without increased soil nitrogen from *Meliltous* roots. Treatments were replicated four times with ten pots per replication in a randomized block design. Laboratory analyses indicated that *Melilotus* treated soils experienced a 248.35% increase in nitrates and a 348.37% increase in ammonium over control soils. Above-ground biomass production of both *Poa* and *Pascopyrum* grown alone and in competition with one another increased in soils with enhanced nitrogen. However, when grown together in *Melilotus* treated pots, *Poa* biomass increased (520.80%) two-fold over that of *Pascopyrum* (257.05%). Our results indicate that Kentucky bluegrass is able to utilize more increased soil nitrogen than native grasses, such as western wheatgrass, which evolved under limited, rather than excess soil nitrogen. Additionally, these results suggest that yellow sweet clover may alter the environment in a manner which facilitates the invasion of Kentucky bluegrass. Therefore, control of either yellow sweet clover or Kentucky bluegrass will require management for both exotic invaders.

4. HABITAT RESTORATION WITHOUT WATER: COMBATING ANNUAL GRASS INVASION WITH A NOVEL DRY HERBICIDE. Shayla Burnett*[1], Jack D. Alexander[1], Dewayne Harper[2], Dan Comingore[3]; [1]Synergy Resource Solutions, Inc, Belgrade, MT, [2]Wilbur-Ellis, Kennewick, WA, [3]Wilbur-Ellis, Madras, OR

Annual grass invasion causes serious degradation of western North American rangelands and shrublands. Managers need tools to reduce habitat degradation and restore converted rangelands.
Liquid-based herbicides provide effective control for annual grass invasion but face several challenges. Physical obstruction of liquid applications by thatch results in patchy control and cheatgrass "halos" around sagebrush where herbicide application was unable to penetrate the brush canopy. The weight of water limits backcountry application. Open Range™ G (ORG) is a novel herbicide formulation that does not require water and improves annual grass control. Wilbur-Ellis® bonded imazapic to granular particles. The high-density granule penetrates vegetation cover to reach the soil surface beneath vegetation canopies and/or annual grass thatch layers allowing the use of low volume rates with application.
Wilbur-Ellis®, Haycreek Ranch, the Oregon Department of Fish and Wildlife (ODFW), and Synergy Resource Solutions, Inc. (Synergy) collaborated to evaluate the ability of ORG to control invasive annual grasses in rangeland ecosystems. In September 2015, we established plots, collected pretreatment data, and applied a preemergent ORG treatment at 4 sites in central Oregon. Sites contained native bunchgrass communities but were dominated by invasive annual grasses with thatch accumulations and/or thick vegetation canopies. Monitoring in June 2016 showed that ORG significantly reduced ventenata, medusahead, and cheatgrass cover and production.
The trial demonstrates the ability of ORG to penetrate thick vegetative cover to reach the soil surface and provide effective control of annual grasses with little harm to desirable species at low application rates. Because ORG gives managers another restoration tool for weed and fire management, its unique advantages challenge us to rethink restoration options, treatment thresholds, and consider the viability of treating low-level infestations that were previously not economically viable. This could change the relationship of economic restoration thresholds with environmental restoration thresholds.

5. CARE & SHARE IDAHO RANGELANDS: A CAMPAIGN TO REDUCE CONFLICTS ON PUBLIC LAND. Gretchen Hyde*; Idaho Rangeland Resource Commission, Emmett, ID

The Idaho Rangeland Resource Commission (IRRC) is an Idaho state agency created by the Idaho legislature in 1994. The mission is to provide public relations and outreach campaigns to increase support and understanding of rangeland management and ecology. The governor appoints Idaho ranchers to the IRRC board who serve a maximum of two five-year terms. The Bureau of Land Management (BLM), US Forest Service (USFS), Idaho Fish & Game, Natural Resource Conservation Service, Idaho Department of Lands, Idaho Department of Agriculture, University of Idaho, Idaho Rangeland Committee and Idaho Section of SRM are all advisory members to IRRC.

The Care/Share campaign is the product of several discussions, public opinion polls, and assistance agreements with BLM and USFS. This campaign targets recreational users with information about local grazing allotments, guidance on interacting with livestock, and maps to help make their experience a positive one. Trailhead signs, brochures, and long-term kiosks provide historical context, management techniques, and basic information about the location and timing of livestock grazing in high to moderate use recreational areas on public land. Reduced conflicts and complaints from recreationists about livestock grazing to local BLM and USFS offices are benefits of this program. This campaign has been active for over ten years.

The Care/Share campaign now includes online resources, social media posts, NPR underwriting messages, educational activities, and trailhead signs in many of the areas where outdoor recreation intersects with livestock grazing across Idaho. IRRC believes this proactive campaign is beneficial to the livestock permittees, the recreational users, and the public land managers. The IRRC encourages other states to develop this type of campaign for the benefit of all who live, work, and play on rangeland.

6. PROCESS-BASED MODELING OF UPLAND EROSION AND SALT LOAD IN THE UPPER COLORADO RIVER BASIN. Sayjro K. Nouwakpo*[1], Mark A. Weltz[2], Colleen Green[3], Sandra Y. Li[4]; [1]University of Nevada, Reno, Reno, NV, [2]USDA Agricultural Research Service, Reno, NV, [3]USDI Bureau of Land Management, Denver, CO, [4]USDA-ARS-GBRRU, Reno, NV

The Colorado River is a vital resource in the United States and Mexico but is susceptible to detrimental salinity levels with salinity-related damages estimated at $385 million per year. Over 55% of sediment and salts entering the Colorado River is of natural origin with a significant contribution from accelerated soil erosion on federal rangelands. This suggests a significant potential to reduce dissolved-solids loading to the Colorado River through land and water-management activities on rangelands. In this study, we aim to develop parameter estimation equations that are valid on saline rangeland sites for use in the Rangeland Hydrology and Erosion Model (RHEM). By combining advanced 3D reconstructions techniques with traditional soil erosion and runoff assessment on 72 in-situ rainfall simulation plots, a unique insight into sediment transport processes on sparsely-vegetated landscapes was possible leading to improved salt load predictions. Long-assumed empirical links between sediment concentration and dissolved solids (salts) were verified and provided a foundation for predicting salt load with RHEM. At the fundamental level, this research is providing a unique opportunity to accurately address topics related to hillslope connectivity, sediment delivery ratio and concentrated flow erosion.

7. NONNATIVE THISTLE DISTRIBUTION AND ABUNDANCE ON A DISTURBED LANDSCAPE IN VALLES CALDERA NATION PRESERVE. Neil P. Estes*[1], Robert R. Parmenter[2], Warren Conway[1], Robert Cox[1], Robin Verble-Pearson[1]; [1]Texas Tech University, Lubbock, TX, [2]Valles Caldera National Preserve, Jemez Springs, NM

Nonnative species are an important threat to rangeland health and productivity. In New Mexican highland range, three native and three nonnative species of thistle are distributed across a patchy and disturbed landscape with only one native, *Cirsium pallidum*, and one nonnative species, *Cirsium vulgare*, being present in significant numbers. We measured thistle abundance and distribution using road surveys and targeted search efforts. We then correlated thistle distribution to burn severity data from the 2011 Las Conchas Wildfire and 2013 Thompson Ridge Wildfire as well as areas undergoing restoration for each species of significant. Preliminary data show that *C. vulgare* occurred more frequently at burned sites with 7 clusters found in burned areas and no clusters found in unburned area and our native thistle of interest, *C. pallidum*, occurred more frequently at unburned sites with no native thistle clusters found in high severity burned areas. Furthermore, it appears that areas of dense forest that are being thinned to mitigate fire danger may present the same nonnative thistle response as areas impacted by high severity burns with 8 clusters of *C. vulgare* found in areas being thinned. These results will help land managers in the future plan for thistle occurrence in areas of high disturbance such as those impacted by restoration efforts or fire

8. PASTURE, RANGELANDS, AND GRASSLANDS IN THE PACIFIC NORTHWEST. Glenn Shewmaker*; University of Idaho, Kimberly, ID

Forages support livestock industries and rank second among all farm commodities for on-farm cash value in the PNW states of Oregon, Washington, and Idaho. Eight percent of cropland is classified as pasture for a total of 660,330 acres. There are 18.5 million acres of permanent pasture and rangeland in addition to cropland and woodland pasture area under private ownership, and 35.6 million acres of rangeland under public management. The proportion of total forage land area classified as rangeland is 9% in Washington, 15% in Oregon, and 41% in Idaho. Sixty-two percent of Idaho's land area produces forage, including approximately 47% of the state's acreage suitable for crop production. In addition, domestic and wild animals graze some forest land. Forages are an essential component of livestock production, making up nearly 80% of the diet of the 4.5 million cattle in the PNW. Forage crops in the PNW such as alfalfa (lucerne) (*Medicago sativa* L.) and other hay crops were valued at $2.6 billion, 12% of total U.S. forage value for 2014. Forage, pasture, and range lands in the PNW are vital to sustainable agriculture in the region.

9. A COLLABORATIVE APPROACH TO OPTIMIZE EROSION AND WATER QUALITY ESTIMATION TOOLS FOR LAND MANAGERS. Sandra Y. Li*[1], Jacob D. Phillips[2], Sayjro K. Nouwakpo[2], Mark A. Weltz[3]; [1]USDA-ARS-GBRRU, Reno, NV, [2]University of Nevada, Reno, Reno, NV, [3]USDA Agricultural Research Service, Reno, NV

Water availability and water quality have long been an area of concern for land managers in arid and semi-arid rangelands. The RHEM (Rangeland Hydrology and Erosion

Model) was developed by USDA ARS as a science-based tool for land managers to predict runoff and erosion on rangelands. RHEM was developed from rainfall simulation experiments out of no less than 20 sites throughout the west. RHEM has proved to be a robust model on non-saline rangelands; however, rainfall simulation experiments presently conducted in the Upper Colorado River Basin are now being used to address concerns about salt and sediment transport on saline rangelands. We will present some of the research used to collect data for characterizing runoff and erosion processes and salt and sediment transport. Current research conducted by ARS Reno has yielded results that are being used to continuously refine RHEM and adapt it for use on saline soils. This ongoing research in addition to the formation of the ARES (Agricultural Runoff, Erosion, and Salinity) database will serve as a growing repository of rainfall simulation data for researchers and managers to explore archived data from past and present experiments. The data populating the ARES database are from a variety of different researchers from many different geographic locations spanning more than 30 years. These data will continuously improve the ability of scientists to refine the tools allowing managers to integrate water availability and water quality concerns with other conservation efforts. All of these critical components are part of a collaborative approach to improve the collective knowledge of rangeland hydrology research informing land management goals.

10. IMPACT OF KENTUCKY BLUEGRASS ON BIOMASS PRODUCTION AND SPECIES DIVERSITY. John R. Hendrickson*[1], Mark A. Liebig[1], Jeffrey L. Printz[2], David Toledo[3]; [1]USDA-ARS, Mandan, ND, [2]USDA-NRCS (Retired), Lisbon, ND, [3]USDA-ARS, Bismarck, ND

Rangelands in the northern Great Plains have been heavily invaded by Kentucky bluegrass. While the extent of the invasion has been recognized, the ecological impact of the invasion needs further attention. We evaluated species productivity, litter production, species diversity and effective number of species on paired sites with either a high or low level of Kentucky bluegrass abundance. Each paired site was 1 x 2 m and located adjacent to each other. Two 1/8 m2 quadrats were clipped in each plot. Quadrats were clipped to ground level and biomass was separated by species. Litter was comprised of both standing dead and detached litter. Species diversity was determined using the Shannon –Weaver index and a variant of the index was used to determine effective species number. Plots dominated by Kentucky bluegrass produced almost 10 more grams of biomass per m2 than did the control plots (46.97 vs. 37.10 g for Kentucky bluegrass and control respectively). Biomass productivity was greater in 2014 compared to 2013 (49 vs 33 g m2 for 2014 and 2013 respectively). Kentucky bluegrass dominated plots produced over 6 times the litter as control plots. Species diversity as measured by the Shannon-Weaver index and species richness was greater in the control plots. Over 5 more species were found in the control plots compared to the Kentucky bluegrass dominated plots and the effective species number was almost twice as great in the control plots (4.78 vs. 2.43 for the control vs Kentucky bluegrass dominated respectively). While Kentucky bluegrass did increase biomass productivity, it dramatically decreased species diversity. The decline in species diversity linked with Kentucky bluegrass can have

impacts on other ecosystem services such as pollination, genetic and medicinal resources.

11. EVALUATION OF CATTLE GRAZING USE WHEN APPLYING RAFFINATE TO LEAFY SPURGE-INVADED RANGELANDS. Tracy L. Ellig*[1], Kevin K. Sedivec[1], Dennis Whitted[1], Ryan F. Limb[1], Kent A. Belland[2]; [1]North Dakota State University, Fargo, ND, [2]North Dakota Army National Guard, Bismarck, ND

Leafy spurge (*Euphorbia esula* L.) is a noxious weed that threatens grasslands throughout the northern Great Plains. Leafy spurge threatens prairie communities by displacing native species and reducing diversity. Leafy spurge is not grazed by cattle. Effective management of this plant requires awareness of practices available for control. Today, herbicides remain the most effective and commonly used practice to manage leafy spurge. However, if we can change the grazing behavior of cattle to consume leafy spurge, we would convert a weed into a valuable forage. In this study we tested the use of raffinate, a molasses extract, as a spray on feed attractant to increase forage and feed palatability of leafy spurge. The study consisted of three treatments to include 100% raffinate, 50% raffinate:50% water mixture, salt blocks and a control using a random block design with three replicates. The study was conducted on the Gilbert C. Grafton Military Training Base (South Unit) near McHenry, ND. Treatments were grazed with cow/calf pairs throughout the study duration. Treatments were applied in mid-June, mid-July and again in early September. Study objectives were to 1) determine if raffinate applied at two different ratios would attract cattle to consume leafy spurge and 2) determine if cattle grazing leafy spurge would alter the plant community over time. Degree of disappearance was determined by clipping 0.25 m2 plots systematically place in all treatments every 8 m at the end of the grazing season. Plant composition was determined by collecting graminoid species presence;absence using 0.1m2 every 5 m and density of leafy spurge and other broad leaf forbs using a 0.25m2 plot every 5 m. Research data is currently being analyzed. Based on our observations during the data collection periods, cattle grazed leafy spurge at a higher rate on the 100% raffinate and salt block treatments.

12. QUANTIFYING SHRUB CANOPY INTERCEPTION OF TWO IMAZAPIC FORMULATIONS AND IMPACTS ON CHEATGRASS BIOMASS. Clay W. Wood*[1], Brian A. Mealor[2]; [1]University of Wyoming, Laramie, WY, [2]University of Wyoming, Sheridan, WY

Herbicides, commonly imazapic, are widely used for cheatgrass (*Bromus tectorum*) control on western U.S. rangelands. Interception by shrub canopies may reduce the amount of herbicide reaching the soil surface or target species. The objective of this research is to compare the efficacy of a granular formulation of imazapic (Open Range G) to the widely-used liquid formulation (Plateau) for cheatgrass control beneath existing shrub canopies. We aerially applied both formulations of imazapic at 123 g ai·ha-1 for

the liquid formulation and at 135 g ai·ha-1 for the granular formulation at two field sites (Saratoga and Pinedale, Wyoming) in 2015 with an untreated check at each site. In 2016, we collected cheatgrass biomass beneath shrub canopies and within interspaces between shrubs at both sites. No differences were detected between cheatgrass biomass beneath shrubs or in interspaces one year post-treatment at Saratoga (p=0.68) or Pinedale (p=0.78). Herbicide treatment was the only factor affecting cheatgrass biomass at Saratoga (p<0.0001) and Pinedale (p=0.0483). At Saratoga, both imazapic formulations provided similar reductions in cheatgrass biomass compared to the check, but at Pinedale, the liquid formulation reduced cheatgrass biomass more than the granular. To directly quantify herbicide reaching the soil surface, we used water sensitive paper for liquid imazapic and 2.37 liter buckets for granular imazapic to determine coverage of each formulation at two additional field sites (Hyattville and Sheridan) during aerial herbicide applications in 2016. Liquid imazapic coverage (%) was significantly greater in interspaces than under shrubs at Hyattville (p<0.0001) and Sheridan (p=0.0005). Granular imazapic weight (g ha-1) was not different under shrubs or within interspaces at both Hyattville (p=0.77) and Sheridan (p=0.72). Due to differences in application equipment and sites, cheatgrass biomass will be sampled under shrubs and within interspaces at all four field sites in 2017 to determine if similar results are achieved.

13. FIRE AND *VENTENATA DUBIA* ON THE PACIFIC NORTHWEST BUNCHGRASS PRAIRIE. Luke W. Ridder*[1], JoAnna M. Perren[1], Lesley R. Morris[1], Bryan A. Endress[1], Josh Averett[1], Robert V. Taylor[2], Bridgett Naylor[3]; [1]Oregon State University, La Grande, OR, [2]National Wildlife Refuge Association, Enterprise, OR, [3]USDA Forest Service, La Grande, OR

Ventenata *(Ventenata dubia)* is an invasive annual grass that is rapidly becoming a serious threat to prairie ecosystems. Our previous findings regarding the increase in ventenata suggested that, unlike cheatgrass (*Bromus tectorum*), this invasive grass has been increasing regardless of fire and that fire has not necessarily facilitated its spread. However, annual variation in precipitation is linked to the production of annual grasses and can vary widely year to year. Therefore, our objective in this study was to evaluate the role of annual variation in ventenata abundance on burned/unburned sites by resurveying frequency and cover on plots sampled in 2008 and 2015. Specifically, we asked 1) Did sample year determine the change in ventenata abundance across all sites? 2) Did sample year determine ventenata abundance on burned/unburned sites? and 3) Did sample year determine if there was more ventenata in burned/unburned plots within a sampling year? We found that differences in ventenata appear to be related primarily to differences in precipitation between 2015 and 2016 rather than fire history of the sites. Support for this can be seen in our results showing frequency of ventenata had not significantly increased in the last year, although it had since 2008. Also, that frequency was not different between burned/unburned plots regardless of sampling year. In contrast, ventenata cover had increased in the last year across all plots, closely following different inter-annual precipitation patterns. Furthermore, it only increased on the unburned plots and there were no significant differences between burned/unburned plots within the same sampling year. Our findings suggest that the cover of ventenata is more sensitive to

differences in annual precipitation than to historical fire and that fire may not be a driving factor in the expansion of ventenata in this prairie system.

14. THE USE OF TAX PLANNING, FINANCIAL CONTROLS, AND BIG DATA FOR INDEPENDANT GRAZING OPERATIONS. Matt B. Crowley*; University of Wyoming, Laramie, WY

The modern age of technology and mechanization has led to the rise of industrial agriculture and an increase in corporate livestock operations and "Big business" involvement in the industry. As a result, independent farmers and ranchers are being forced to compete with entities that are characterized by low-cost and high-output. The purpose of this study is to provide a detailed analysis of financial and tax accounting concepts that can be used by smaller livestock producers to lower costs and increase competitive advantage. By highlighting the unique performance metrics governing financial controls over a livestock production operation, this study will provide insight into the implementation of an accounting system capable of efficiently generating useful reports, accurate budgets, and long-term usefulness for the operator with regard to the unique reporting needs of an agriculture operation. This poster will also analyze ways that producers can benefit from understanding specific tax laws governing agriculture businesses and the tax planning opportunities that will result from implementing a financial accounting system congruent with tax law. Finally, this study will discuss the usefulness of "Big Data" for independent producers and how it can be used as both an input to their accounting system and a budgetary planning tool. By understanding these subjects, viewers of this poster will be able to highlight low-cost ways to generate greater returns from livestock operations, which will result in long term success of business and health of the ecosystem upon which it operates.

15. SPATIAL INTERPOLATION OF ANNUAL RAINFALL DATA FOR ARIZONA GRAZING ALLOTMENTS WITHIN A NATIONAL DATASET GAP. Charles S. Perry*[1], Ashley L. Hall[2]; [1]University of Arizona - Cooperative Extension, Yuma, AZ, [2]University of Arizona - Cooperative Extension, Globe, AZ

National rainfall datasets have limited coverage in the Sonoran Desert region of Southwest Arizona. Due to the large geographical area which needs to be covered, and the limited rain gauge locations, it can be impractical to use the national precipitation dataset estimations on a local scale. The Arizona Cooperative Rangeland Monitoring Program (ACRMP) has placed rain gauges at all of its vegetation monitoring key areas in La Paz County, Arizona, in an effort to better understand the local annual rainfall patterns in grazing allotments that are underserved by the national datasets. Spatial interpolation is a useful tool for estimating rainfall patterns in areas between rain gauges. Through the use of the ArcGIS inverse distance weighted (IDW) interpolation tool, it is possible to calculate a simple gradient of rainfall over a large area which could not be feasibly measured otherwise. The local rain gauge IDW interpolation is compared with the national precipitation estimates to further refine the accuracy. The resulting geostatistical

model can help land managers and land users working with the ACRMP to visually understand local climate irregularities so they can make more informed decisions.

16. WILL CLIMATE CHANGE AFFECT INTER-SPECIFIC COMPETITION BETWEEN NATIVE AND INVASIVE GRASSES THROUGH SEED GERMINATION? Heidi A. Becker*[1], Lan Xu[1], Jack L. Butler[2], Brent Turnipseed[1]; [1]South Dakota State University, Brookings, SD, [2]US Forest Service, Rapid City, SD

Predicted changes in precipitation and temperature associated with climate change may profoundly impact grassland community structure and function by affecting competitive dynamics between native and invasive species, potentially undermining the effectiveness of restoration activities. In the Northern Great Plains, invasive grasses smooth bromegrass (*Bromus inermis*) and Kentucky bluegrass (*Poa pratensis*) are rapidly invading large area of native prairie, replace native species, such as western wheatgrass (*Pascopyron smithii*), and decrease biodiversity. Although it is known that smooth bromegrass outcompetes with western wheatgrass, the effects of climate change on their seed germination and therefore competitive advantage is lesser known. The objective of this study was to examine how temperature altered seed germination of invasive smooth bromegrass and native western wheatgrass. Treatments consisted of the combination of two pre-treatment conditions (stratified and non-stratified) and ten temperature regimes including six alternating temperatures ($10^oC/15^oC$, $10^oC/20^oC$, $15^oC/25^oC$, $15^oC/20^oC$, $15^oC/30^oC$, $20^oC/30^oC$) and four constant temperatures (15^oC, 20^oC, 25^oC, and 30^oC) in growth chambers. Sets of uniform fifty seeds were planted on two layers of blotter paper in 12-cm x 12-cm plastic germination boxes with four replications per treatment. Seeds receiving the stratified treatment were pre-chilled at 5^oC for five days prior to being in a designated temperature chamber. Germination counts were conducted at 7, 14, 21, and 28 days after temperature treatment began. Germination rate and speed over a range of temperatures and pre-treatment conditions between smooth bromegrass and western wheatgrass will be analyzed. This study will elucidate the mechanisms of competitive interactions between native and invasive grasses in response to the climate change. In addition, it will provide scientific-based knowledge for land managers to develop management strategies and tools to sustain resilience of prairie ecosystems under future climatic shifts.

17. EVALUATING LOCAL AND DISTANCE DELIVERY OF SOIL AND VEGETATION MANAGEMENT WORKSHOPS ON THE KENAI PENINSULA. C. A. Matney*; University of Alaska Fairbanks, Fairbanks, AK

The Kenai Peninsula is one of the largest and fastest growing agricultural areas in Alaska. Considering where future agricultural growth could occur, there is great potential for an increase in rangeland and livestock production. However, land managers across the peninsula are in need of educational programming covering topics of soil and

vegetation management. Part of this need stems from both limited access to the internet as well as having to travel long distances to attend educational events. Improved methods of educational program delivery are needed. In order to address these challenges, a series of soil and vegetation workshops were delivered on the peninsula from two technology classrooms: Kenai Peninsula College Kachemak Bay Campus and Kenai Peninsula College Soldotna Campus. These workshops were simultaneously delivered, with the primary source location occurring in-person and the secondary location receiving the presentation via distance delivery. The location of the primary and secondary locations were alternated between Homer and Soldotna for a total of five soil and vegetation workshops. At the conclusion of each workshop, participants were asked to respond to a survey to evaluate the quality of the presentation, distance travelled, as well as information learned. This poster will present the results of a comparison between local and distance programming and identify possible opportunities to improve future educational programs.

18. ARES DATABASE, **A**RCHIVE FOR **R**AINFALL AND **E**ROSION **S**IMULATIONS TO BETTER EVALUATE RANGELAND STATE AND SUSTAINABILITY. Jason Nesbit*[1], Timothy J. Jones[1], Mark A. Weltz[2], Ken McGwire[3], Sayjro K. Nouwakpo[4], Sandra Y. Li[5]; [1]USDA-ARS, Reno, NV, [2]USDA Agricultural Research Service, Reno, NV, [3]Desert Research Institute, Reno, NV, [4]University of Nevada, Reno, Reno, NV, [5]USDA-ARS-GBRRU, Reno, NV

Historically, information on the types, patterns, causes, spatial location, severity, and extent of land degradation through soil erosion at global or national scales have not been available in sufficient detail for developing specific polices for targeting conservation in a cost-effective approach. Over 55% of sediment and salts entering the Colorado River are derived from accelerated soil erosion from federal rangelands with damages estimated to be $385 million per year to water users. Management tools to reduce dissolved-solids loading to the Colorado River through land- and water-management activities on rangelands are needed. ARS and it partners NRCS, BLM, USFS and BOR have implemented large scale experiments to evaluate rainfall/runoff/soil loss/water quality on rangelands for the last 40 years using rainfall/erosion simulators. ARS scientists working with a team of National Agricultural Library (NAL) IT Specialists are developing a relational database to archive this data on NAL servers for public access and sustainability. The data will have sites cross referenced to NRCS soil series and ecological site databases. This new database with over 73 plant communities and 2,000 plots/runs will be used to validate and expand the utility of Rangeland Hydrology and Erosion Model (RHEM) for plant communities not currently addressed by RHEM (i.e., meadows, salt desert shrubs, CRP grasslands, etc.); develop new equations to estimate total dissolved solids in runoff water; and use RHEM to develop standardized hydrologic section for NRCS rangeland Ecological Site Descriptions that describes optimum vegetation cover for reducing soil erosion and improving water quality. The RHEM model supported with the database will provide data immediately to USDA scientists and

partners to improve its conservation planning tools for estimating soil erosion and salt transport processes on rangelands.

19. IS *VENTENATA DUBIA* CONDITIONING THE SOIL TO BENEFIT ITS INVASION? Luke W. Ridder[1], Marisa Mode*[1], Lesley R. Morris[1], Christo Morris[2]; [1]Oregon State University, La Grande, OR, [2]Powder Basin Watershed Council, La Grande, OR

Invasions of non-native plants can cause both environmental and economic damage to a region, including increased wildfires, reduced forage for livestock, degraded wildlife habitat and changes in watershed function. *Ventenata dubia* is a relatively new invasive annual grass to the Intermountain West that has spread rapidly across seven western states (CA, OR, ID, WY, WA, UT, MT). There are many ways that plants from other parts of the world are able to move into a new environment and become the dominant plant. One of these invasion tactics, called "soil conditioning", involves the ability of some plants to alter the soil in a way that promotes its own growth while inhibiting growth from competing plants. Plants can do this in several different ways including altering nutrient levels, changing the microbial community in the soil, or by secreting poisons that affect other plants. The objective in this study was to examine if ventenata is using soil conditioning (altering soils in a way that benefits itself while inhibiting other vegetation) as a mechanism to assist in its invasion. To test this, we compared the final biomass of the native grass bluebunch wheatgrass (*Pseudoroegnaria spicata*) to the final biomass of ventenata grown in a greenhouse in pots of field-collected soils that were in close proximity and either "conditioned" or "non-conditioned" by ventenata in the same soil type from two different sites. Our results were not consistent across sites, suggesting that either this species is not using soil conditioning to its advantage, has not been on site long enough in both locations to affect changes in soils, or that other soil physical and chemical characteristics of the soil are responsible for the different responses.

20. RUNOFF AND SOIL EROSION FROM TWO RANGELAND SITES. Timothy J. Jones*[1], Gary Frasier[2], Nesbit Jason[1], Mark A. Weltz[3]; [1]USDA-ARS, Reno, NV, [2]USDA-ARS, Loveland, CO, [3]USDA Agricultural Research Service, Reno, NV

Historically over 50 years of rainfall/runoff research using rainfall simulators has been conducted at various rangeland sites in the West, however these sites rarely have consecutive yearly measurements. This limits the understanding of dynamic annual conditions and the interactions of grazing, plant productivity, and annual weed presence on runoff, infiltration and erosion. Rainfall runoff was measured with a rotating boom rainfall simulator on plots defined as light, moderate and heavy grazing. Simulations were conducted for three consecutive years at the Central Plains Experimental Range, Nunn CO. This site has had 53 years of known grazing (*Bouteloua gracilis* (H.B.K.), *Buchloe dactyloides* (Nutt.) Engleman). Simulations were also conducted at the High Plains Grasslands Research Station, Cheyenne WY, with 12 years of recorded grazing (*Bouteloua gracilis* (H.B.K.), *Pascopyrum smithii* (Rydb.)) The

simulator rained on 3 x 10 m plot pairs with controlled rainfall amounts and intensities. Simulations were conducted when the soil was dry, wet and very wet. Raining on dry soil allowed evaluation of vegetation, surface roughness, and soil hydrophobicity on water infiltration. Raining on wet soil measured the effects of soil bulk density and soil organic matter on runoff and infiltration. At the High Plains Grassland Research Station heavy grazing resulted in the greatest runoff, however light grazing showed more runoff than the moderate grazing treatment. At the Central Plains Experimental Range heavy grazing similarly showed higher runoff rates than lower intensity grazing. Decreasing heavy grazing at the Colorado site resulted in a decrease in runoff within a year of the decrease over the 3 year study period. In conclusion while grazing intensity can effect runoff rates the effect is short term and can be reduced with rotational pasture use.

21. TRANSITIONING LCTA TO RANGELAND HEALTH ASSESSMENTS GIVES A 20-YEAR RECORD FOR ADAPTIVE MANAGEMENT. Douglas Johnson*; Utah National Guard, Bluffdale, UT
The Department of the Army started landscape-level vegetation monitoring at major installations in the late 1980s through the Land Condition Trend Analysis Program. A change in program proponency shifted emphasis away from permanent plots. At Camp Williams, 97 plots representing 24,000 acres were monitored annually through 2006 when funding was reprioritized. The same locations were resurveyed using Rangeland Health Assessment methodology in 2011 and 2014 as an input into adaptive natural resource management. A key measurement of both methods is a 100-meter point-line intercept cover count. Rangeland Health Assessment with 20 years of vegetation cover data provides useful information to assess the training landscape and vegetation communities that is incorporated into the Integrated Natural Resource Management Plan (INRMP). The 2014 assessment showed landscape changes in Biotic Integrity, including a shift in indicators for functional groups, increase in invasive plants and bare ground, and evidence of a loss of soil surface-water resistence. While wildfire is a leading suspect for causes, the increase in cheatgrass has implications for wildfire hazard. The revised INRMP focuses on reversing annual grass invasion directly through control and indirectly through protecting plant communities from conversion by fire. Within juniper stands, analysis of cover data showed a threshold in juniper canopy cover at 35-40% where shrub and native herbaceous plants are eliminated and annual grass remains. Thinning of juniper to 20-30% leads to significant understory improvement and training site desirability. Researchers at Utah State University are analyzing climate change and implications with the data as well.

22. SURVEY ON DEMOGRAPHICS, MOTIVATIONS, AND EXPERIENCES OF PRODUCERS PARTICIPATING IN THE ENVIRONMENTAL QUALITY INCENTIVES PROGRAM. . John A. Tanaka, Anna C. Collins*; University of Wyoming, Laramie, WY

Government payment incentives programs are an important method to encourage and assist in the adoption of conservation practices on rangelands. The Natural Resource Conservation Service's Environmental Quality Incentives Program and the Conservation Securities Program are two federal programs that provide significant funding for approved conservation practices. Through a Freedom of Information Act request, the NRCS provided us with a nationwide list of current contracts for nine rangeland related practices. These practices are brush management, forage and biomass planting, grazing land mechanical treatment, range planting, herbaceous weed control, prescribed burning, prescribed grazing, riparian herbaceous cover, and upland wildlife habitat management. Our survey will be sent out to a random sample of producers in all 50 states and territories. The goal of our research survey is to determine the characteristics of producers who participate in these two programs, as well as their motivations and their experiences while participating. Literature suggests that those who participate in payment or cost share programs are typically motivated by a strong feeling of stewardship, economic benefits, and government regulations. The possibility of using Department of Agriculture Census data to compare demographics of participants to national averages will also be explored. By identifying motivations and experiences that participants may encounter before and during the program will give the NRCS and other agencies a better idea of how to increase contracting, retain current contracts, as well as make their programs more efficient.

23. IDENTIFYING SMOOTH BROME (*BROMUS INERMIS*) ELONGATION IN THE NORTHERN TALLGRASS PRAIRIE USING GROWING DEGREE DAYS . Lisa Preister[1], Edward S. DeKeyser*[1], Cami Dixon[2]; [1]North Dakota State University, Fargo, ND, [2]U. S. Fish and Wildlife Service, Woodworth, ND

The US Fish and Wildlife Service uses the number of leaves as a phenological cue, in which development of the five-leaf stage serves as a signal to the initiation of elongation in smooth brome (*Bromus inermis*). In areas where certain plant community criteria are met, conducting a prescribed burn at the onset of elongation has been shown to reduce smooth brome population. However, leaf stage identification has presented USFWS managers with challenges, due to the variability of smooth brome development in Tallgrass Prairies of the northern Great Plains. This project addresses the issue of variability by seeking an alternative method for developmental staging, ultimately linking growing degree days and mean stage count to identify the elongation phase of smooth brome populations throughout the region. Sites in North Dakota, South Dakota and Minnesota were identified and smooth brome phenological stages were determined, as well as the corresponding number of growing degree days. The correlation between phenological stage and growing degree days allows for the identification of expected onset of elongation in the smooth brome population, regardless of leaf stage variation. As part of the USFWS Native Prairie Adaptive Management program, results will be used to assist in management decisions regarding the timing of burning and grazing in an effort to enhance the native plant communities where smooth brome is the dominant invader.

24. ANALYTICAL APPROACHES TO QUALITY ASSURANCE AND QUALITY CONTROL IN RANGELAND MONITORING DATA. Sarah E. McCord*, Jason W. Karl, Justin W. Van Zee, Ericha M. Courtright; USDA-ARS, Las Cruces, NM
Producing quality data to support land management decisions is the goal of every rangeland monitoring program. However, the results of quality assurance (QA) and quality control (QC) efforts to improve data quality are rarely reported. The purpose of QA and QC is to prevent and describe non-sampling errors that introduce noise into monitoring datasets, thereby increasing the repeatability, defensibility, and usability of the data collected. Quality assurance is a proactive process designed to prevent errors from occurring, while QC is a reactive process whereby the number, nature, and implications of errors are identified. Common QA practices include careful design and documentation of the monitoring programs and protocols; training and calibration of data collectors; and structured management of resulting data. Quality control describes errors via data checks for incomplete or invalid values, variance decomposition, and evaluation of signal-to-noise ratios. We analyzed the calibration results and field data of two national monitoring datasets collected between 2011 and 2016. Field and lab calibration data demonstrate that the iterative learning by data collectors which occurs in QA improves field sampling results and can point to areas of future training. We also explored quantitative QC approaches for identifying and visualizing erroneous observations by comparing results to other data sources; and analyzing between-observer variability, patterns of missing data, and seasonal trends in method implementation - all of which help to describe the errors in these national datasets. We conclude that the results of the QA and QC processes can and should be evaluated to improve and document the quality of monitoring data. These evaluations can be used to improve monitoring data collection efforts and to support the role of rangeland monitoring in decision making.

25. USING STATE-AND-TRANSITION MODELS TO EVALUATE IMPACTS OF LAND COVER CHANGE ON WIND EROSION. Nicholas P. Webb*[1], Magda Galloza[1], Max Bleiweiss[2], Craig Winters[1], Eldon Ayers[1], Jeffrey Herrick[3]; [1]USDA-ARS Jornada Experimental Range, Las Cruces, NM, [2]New Mexico State University, Las Cruces, NM, [3]USDA-ARS, Las Cruces, NM

Wind erosion of rangeland soils is a global problem exacerbated by land cover change. Despite efforts to quantify the impacts of land cover change on wind erosion, assessment uncertainty remains large. We address this uncertainty by evaluating the application of ecological site concepts and state-and-transition models for detecting and describing the impacts of land cover change on wind erosion. We couple a geodatabase of ecological site information with atmospheric data from the Weather Research and Forecasting (WRF) model to run a dust emission model at 1 km spatial resolution over a study area in the northern Chihuahuan Desert, New Mexico, USA. We evaluate spatiotemporal patterns of modelled horizontal sediment mass flux and dust emission in the context of ecological sites and their states; representing a diversity of land cover types. Our results

demonstrate how the impacts of land cover change on wind erosion can be quantified, compared across land cover classes, and interpreted in the context of an ecological model that encapsulates land management intensity and change. Results also reveal weaknesses in the dust emission model's soil characterisation and drag partition scheme, which were largely insensitive to the impacts of land cover change. New models that address these weaknesses, coupled with the ecological site framework and field measurements across land cover types, could significantly reduce assessment uncertainties and provide opportunities for identifying land management options.

26. BUILDING SOFTWARE TOOLS TO HELP CONTEXTUALIZE AND INTERPRET MONITORING DATA. Nelson Stauffer*[1], Jason W. Karl[2]; [1]USDA Jornada Experimental Range, Las Cruces, NM, [2]USDA-ARS, Las Cruces, NM

Even modest monitoring efforts at landscape scales produce large volumes of data.These are most useful if they can be interpreted relative to land potential or other similar sites. However, for many ecological systems reference conditions may not be defined or are poorly described, which hinders understanding what values for a monitoring indicator are acceptable. One solution for this problem is to mine existing monitoring data to examine the distribution of the indicator values across sites and compare the distributions of subsets of the data against each other. In the case of the BLM's Terrestrial Assessment, Inventory, and Monitoring Database (TerrADat), pre-computed indicator values are available for thousands of monitoring locations. By grouping these data by geographic region, land potential (*e.g.* ecological site), or other factors, indicator values in TerrADat can be visualized and analyzed to determine potential indicator ranges, supporting management decisions even though none of the monitoring locations are designated as reference.

We have developed a web-based statistical tool which streamlines histogram-based exploration of TerrADat, giving users a graphical interface to select survey locations to include and which indicators to use. Users can select data from TerrADat to plot using either an uploaded polygon shapefile to restrict spatially or by metadata queries. Figures can include multiple subsets of TerrADat to compare distributions of indicators between landscape units, *e.g.* ecological sites or grazing allotments. Additionally, the tool dynamically adapts its output to reflect common sense visualization rules for clarity. Visualizing indicator value ranges from similar areas can allow users to see, if not how conditions compare to reference, at least how conditions compare to the greater context on the landscape. This can be used to help support decisions about prioritization of management effort or as evidence toward defining what reference conditions are for portions of the landscape.

27. THE USE OF CONSERVATION EASEMENTS TO ACHIEVE LANDSCAPE-SCALE CONSERVATION OBJECTIVES IN THE MADREAN ARCHIPELAGO. Damian N. Rawoot*[1], Mitchel P. McClaran[2], Larry A. Fisher[1]; [1]University of Arizona, TUCSON, AZ, [2]University of Arizona, Tucson, AZ

Although large tracts of public land have been set aside for conservation in the western United States, landscape-scale threats such as climate change and fragmentation of adjacent private lands jeopardize the effectiveness of this network of protected areas. Undeveloped private lands can augment and buffer protected areas, and support landscape connectivity but their sub-division and development at the margins of protected areas further isolates and threatens these areas. Over the past three decades conservation easements (CEs) have emerged as a popular tool for protecting private lands, and as a possible market-based solution to the threat of landscape fragmentation, but as a markets-based mechanism there is no explicit expectation that land protected provides buffer and connectivity values. Within the Madrean Archipelago ecoregion in southern Arizona and New Mexico, of which is 41.5% publically held, more than 137,783 hectares, constituting almost 10% of all private land in the area is protected through CEs. Through a spatial analysis we determined the extent to which CE distribution is preferred near protected area boundaries, and aligned to connect protected areas across the ecoregion. Specifically, we determined the distance of all conservation easements to nearest protected area, the percentage of CE land within various buffer distances from protected areas, and their spatial association to grasslands measured by the percentage of land contained within grasslands, and compared those statistics to those of all private lands across the ecoregion. Results show that CEs are selectively positioned closer to protected areas, and have a strong affinity to grassland conservation areas. These results, coupled with preliminary interviews, suggest that the market-based CE model can contribute to achieving non-market, landscape-scale conversation goals because either "buyers" (organizations that seek, hold and finance CEs) or "sellers" (private landowners), or both parties, see value in strategically expanding the protection "footprint" beyond public protected areas.

28. VEGETATION CHANGES OVER 5 YEARS ON CLAYEY AND LOAMY ECOLOGICAL SITES IN NORTHERN GREAT PLAINS . Jennifer Muscha*[1], Mark Petersen[2]; [1]USDA-ARS Fort Keogh, Miles City, MT, [2]USDA-ARS, Miles City, MT

Vegetation composition in parts of the Northern Great Plains (NGP) varies yearly due to abundance or absence of annual bromes. This study was designed to determine the effects of variability associated with year and two dominate ecological sites (clayey and loamy) on the cover of cool and warm season native grasses and annual bromes. Research was conducted at the 22,257 ha USDA-ARS Fort Keogh LARRL, Miles City, MT, where native vegetation is predominately western wheatgrass (*Pascopyron smithii*), needle and thread (*Hesperostipa comata*), and blue grama (*Bouteloua gracillis*) grasses.   Average annual precipitation is 315 mm of which 80% is received from April-September. Three 50m transects were sampled for percent of canopy cover in 6 pastures, in two ecological sites (ES), clayey or loamy ES, from 2012-2016. Year (5), ES (2), and their interactions

were analyzed using Proc Mixed (SAS 9.4) as a 5 x 2 factorial arrangement of treatments. Needle and thread, and threadleaf sedge (*Carex filifolia*) cover was greater (P<0.05) on loamy than clayey sites and buffalo grass (*Bouteloua dactyloides*), western wheatgrass, and Japanese brome (*Bromus arvensis)* cover was greater (P<0.05) on clayey than loamy sites. Year*ES interacted to influence annual brome and native cool season grass cover. Annual brome cover (P<0.05) was highest in above average spring rainfall years 2013-2014 on clayey ES (32%±3%) and lowest in 2012, a low spring rainfall year, for both ES (1%±3%). Native cool season grass cover (P<0.05) was highest in 2012 for both ES (74%±5%) and in 2013 (64%±5%) and 2014 (61%±5%) in loamy ES. Warm season grass cover was not influenced by ES or year (P>0.05). Abundance of annual bromes in the NGP are highly variably by year, appearing to be reliant on on timing of rainfall events. Long term monitoring is needed to better understand the factors influencing annual brome abundance.

29. EFFECT OF EXCLOSURES THROUGHOUT THE ARIZONA STRIP. Kade P. Willardson*; University of Arizona, St. George, UT

I've selected seven exclosure sites from a list of around 40. These seven sites have been analyzed and monitored for at least 20 to 30 years, depending on the site. I've chosen these seven sites because they show reliable and accurate data over the course of time since they were established. The exclosures were set up to show a comparison between the inside of the exclosure and the outside of the exclosure. We use the pace frequency method to collect data. Pace frequency is where the observer navigates to the destination point while setting the quadrat frame down along the way. We ran four transects inside the exclosure. The four transects have five paces in-between them, so we have enough space to cover the exclosure. Each transect has 50 points for recording, for a total of 200 points/recordings, and one pace between each point/recording. The same is done for the outside of the exclosure. When we are observing, cover type is recorded, as well as frequency, and for the first and third transect dry weight rank is recorded. Repeat photography is also used when monitoring the exclosures. There are certain impacts that could affect the inside and outside of the exclosures. Some impacts include wildlife, livestock, drought, etc. The goal of this study is to see the relationship between the inside of the exclosure and the outside. From analyzing the data I noticed that some of the exclosures show more species on the inside with higher frequency than the outside. Also I've noticed with some exclosures showing the opposite, where more species occur on the outside with a higher frequency than the inside.

30. APPLICATION AND UTILITY OF ECOLOGICAL SITES AND DISTURBANCE RESPONSE GROUPS FOR POST-FIRE GRAZING MANAGEMENT AND REHABILITATION. Devon K. Snyder*[1], Tamzen K. Stringham[2]; [1]University of Nevada Reno, Reno, NV, [2]University of Nevada, Reno, Reno, NV

A Disturbance Response Group (DRG) consolidates ecological sites that respond similarly to disturbance into a larger management unit. This research project aimed to provide ecologically based understanding of the effects of various grazing management strategies on post-fire vegetation in two different DRGs. Five exclosure plots were established in each DRG in areas of northern Nevada that burned in 2012. Treatments were applied in a randomized block design and included both simulated and natural grazing at different times of year and with different lengths of rest from grazing. Vegetation composition, basal gap, annual production, and density of shrub seedlings were measured to quantify response. Climate variables were observed over time to understand the effects precipitation and temperature on native and nonnative plants after wildfire. Project results will demonstrate how land managers may stratify post-fire management decisions across large landscapes based on pre-fire condition, measured plant community response, and quantified ecological thresholds. Results indicate utility of Disturbance Response groups in managing large landscapes.

31. DEVELOPING QUANTITATIVE MANAGEMENT BENCHMARKS TIERED TO RANGELAND HEALTH STANDARDS . Andrew C. Johnson*[1], Sarah E. McCord[2], Landon Gryczkowski[3], Colleen Dulin[4]; [1]Bureau of Land Management, Susanville, CA, [2]USDA-ARS, Las Cruces, NM, [3]US Forest Service, Campton, NH, [4]Bureau of Land Management, Carson City, NV

Creating defensible and ecologically relevant quantitative management benchmarks is critical to successful adaptive management. Quantitative management benchmarks can be tiered directly to applicable rangeland health standards to facilitate using quantitative data in decision making. The availability of robust datasets from national monitoring programs such as the Bureau of Land Management (BLM) Assessment, Inventory, and Monitoring (AIM) program, the Landscape Monitoring Framework, and National Resources Inventory present new opportunities to incorporate quantitative, statically valid data into the BLM's land health evaluation process. However, in this era of "big data," understanding the context of quantitative indicators is crucial. The BLM's Eagle Lake Field Office (ELFO) has developed a method for identifying explicit and quantitative management benchmarks that are tied directly to rangeland health standards and informed by ecological site potential, habitat objectives, and the best available literature. From the Standards for Rangeland Health, applicable quantitative terrestrial indicators were attributed to the upland soils and biodiversity standards. These quantitative indicator benchmarks vary by ecological site potential. Within the field office, 8 terrestrial ecological potential "ecoclusters" were identified by analyzing SSURGO together with local and adjacent ecological site concepts where applicable. For indicators that were not addressed in ecological site descriptions, benchmarks were derived from policy, peer-reviewed literature, and relevant baseline monitoring data. Through the cooperation of the interdisciplinary team, management benchmarks were then decided on and the rational was documented. The monitoring data at each site were then evaluated against the appropriate benchmarks to determine if the land health standard was met for that particular indicator. The ELFO can then use a preponderance of evidence approach across indicators to determine if that standard is met overall. This collaborative and

iterative process represents a starting framework for rationally developing quantitative management benchmarks and documenting the monitoring data evaluation process in a land health evaluation.

32. 4-H IS ROAM'N THROUGH IDAHO – THE RANGELAND OUTREACH ACTIVITY MANUAL AND SKILLATHON COMPETITION. Tyanne Roland*[1], Gretchen Hyde[2]; [1]University of Idaho Extension, Council, ID, [2]Idaho Rangeland Resource Commission, Emmett, ID

Partnering with the Idaho Rangeland Resource Commission, University of Idaho Extension, Adams County 4-H, and with the help of numerous interns, the Idaho 4-H Rangeland Skillathon was created in 2015 with five teams competing and in 2016 with nine teams and two individual competitors. Teams compete in both individual and team competitions. One month prior to the competition, the teams are mailed a box of study materials and a scenario that will be used for their oral presentations, 3-D diorama and written management plan. Teams will also prepare to compete in animal and plant identification, water or soil quality testing, and firebox challenges.
While starting the skillathon, we have also begun creating the Rangeland Outreach Activity Manual. This manual will be piloted with the teams during the 2017 skillathon to prepare them for the competition and further their learning experience. A separate but related curriculum is also being created to be offered for school teachers in a classroom environment.
Our poster will show our roadmap. Come and see how the program started, what we are currently doing, and what the future looks like. We will also show how you can become involved on this trip towards a better informed and more engaged future generation of rangeland enthusiasts.

33. SOUTH DAKOTA GRASSLAND COALITION GRAZING SCHOOL: ASSESSING IMPACTS ON RANCHERS&RSQUO; PERSPECTIVES AND PRACTICES. Andrea M. Beck*[1], Alexander J. Smart[1], Pete Bauman[2], Justin Jessop[3]; [1]South Dakota State University, Brookings, SD, [2]South Dakota State University, Watertown, SD, [3]South Grassland Coalition, Presho, SD

The South Dakota Grassland Coalition has been hosting an annual grazing school for over 10 years. The curriculum was developed to target producers interested in enhancing their livestock production through better grassland management. Classroom presentations and hands-on field experience provided land managers an opportunity to expand their knowledge in a wide variety of topics, from plant species identification to drought management to fencing and watering systems. A survey was generated in assessing the value that ranchers have obtained through this program. The survey consisted of multiple choice questions regarding each topic covered in the grazing school curriculum. The multiple choice answers were designed to evaluate whether the ranchers learned the

importance of the topic and whether or not they implemented the practice on their own operations. A link to the online survey was sent via email to 176 past grazing school participants, and they were given two weeks to complete the survey. The response rate was 13.6%. The majority of the respondents implemented what they learned at the grazing school in their operation and 63% believed they have become more profitable. Nearly all the participants expressed interest in refresher grazing school workshops and provided additional topics they would like to see covered. This survey, albeit a small sample size, has shown that this Grazing School has successfully impacted South Dakota ranchers.

34. GRASSLAND MANAGEMENT GRADUATE CERTIFICATE: REACHING NON-TRADITIONAL, PLACE-BOUND STUDENTS. Alexander J. Smart*[1], Walt Fick[2], Walt Schacht[3], Hickman Karen[4], Jack Norland[5]; [1]South Dakota State University, Brookings, SD, [2]Kansas State University, Manhattan, KS, [3]University of Nebraska-Lincoln, Lincoln, NE, [4]Oklahoma State University, Stillwater, OK, [5]North Dakota State University, Fargo, ND

A growing demand for online course offerings in natural resource management by non-traditional, place bound students, has created a unique opportunity for universities in the Great Plains to invest in a Grassland Management Graduate Certificate through the Great Plains Interactive Distance Education Alliance (GP IDEA). Kansas State University, University of Nebraska, Oklahoma State University, South Dakota State University, and North Dakota State University created a 12-credit graduate certificate in grassland management with course offerings in grassland fire ecology, grassland monitoring and assessment, grassland plant identification, grazing ecology and management, principles of forage quality & evaluation for grazing livestock, watershed management, and ecology of invasive species. Since our first course offerings in 2007, the program has seen a steady increase in student enrollment and credit hour generation from 3 credits in FY 2007 to 108 credit hours in FY 2016. To date, the program has graduated 5 students with a current enrollment of 46 certificate seeking and 72 non-certificate seeking students. The mean age of our student population is 33. The majority come from Oklahoma (32), Kansas (17), South Dakota (11), Nebraska (10), and Texas (9) and represent a total of 19 different states. A survey of students enrolled in two courses in fall 2013 revealed that students found out about the certificate program through online searches, university websites, and from advisors. Most of the students indicated that the certificate would help them move into rangeland management positions, fulfill partial degree requirements towards a master's degree, or expand their knowledge for future job opportunities. In our view, the Grassland Management Graduate Certificate program has been quite successful in providing opportunities for non-traditional, place bound students to meet minor career adjustments.

35. USING AN INTERACTIVE SCENARIO-PLANNING TOOL FOR RANCHERS AND FOREST SERVICE TO PREPARE FOR DROUGHT. Kelsey L. Hawkes*[1],

Mitchel P. McClaran[1], Julie Brugger[1], Michael A. Crimmins[2], Larry Howery[1], George Ruyle[1], James Sprinkle[3], Douglas Tolleson[4]; [1]University of Arizona, Tucson, AZ, [2]The University of Arizona, Tucson, AZ, [3]University of Idaho, Salmon, ID, [4]Texas A & M University, Sonora, TX

Decision-making for livestock management on Southwest national forests is challenging because those decisions must involve both the private rancher (permittee) and the Forest Service. When making decisions to increase preparation for drought on livestock allotments, those two parties should work together to co-develop management strategies that can both reduce a livestock operation's vulnerability to drought impacts and be approved by the Forest Service through the NEPA (National Environmental Policy Act) process. To facilitate co-development and conversations about drought preparation, we used a hypothetical, but realistic ranch and a scenario-planning exercise inspired by the Protection Motivation Theory at a one-day workshop that involved ranchers, District Rangers, and rangeland specialist staff from the Tonto National Forest, Arizona. I developed an interactive Microsoft Excel©-based Drought Scenario Planning Tool to facilitate the scenario planning exercise. Results of the exercise indicate that the scenario planning exercise successfully helped the participants to co-learn about drought impacts and frequency (via the Standardized Precipitation Index), co-develop strategic preparatory coping practices, and develop more realistic expectations of the Forest Service approval process for practices; the Tool was a critical to that success. In addition, the use of co-development resulted in high levels of constructive interactions and communication between participants. There is some evidence that the workshop participants have begun to feel motivated to prepare for drought on actual livestock grazing allotments. However, a major challenge to collaborative drought preparation is the high turnover in Forest Service employees and a frustration with inconsistency in discretionary decision-making by Forest Service District Rangers; these challenges might be overcome by adopting standards for drought planning and preparation into Forest Service policy. A follow-up study might help the participants begin developing drought plans for actual allotments.

36. A 30-YEAR EVALUATION OF EXCLOSURE COMPARISON SITES IN NORTHWEST ARIZONA. Ariana I. Gloria*; University of Arizona Cooperative Extension, Kingman, AZ

Standardized rangeland monitoring methods (ground point cover, pace frequency, dry-weight rank and repeat photography) have been carried out on a 160 acre exclosure located on public land in the Hualapai Valley of Arizona since 1986 to assess long-term vegetation trend. The objective of this project was to compare the vegetation trend inside and outside of the exclosure. From 1980 to 1999, the outside of the exclosure was on a deferred grazing system. From 2002 to 2011, the outside of the exclosure was grazed year round. Since 2011, the outside of the exclosure has not been grazed. Climate data in the Hualapai Valley over the span of the last 30 years is expressed through the Standard Precipitation Evapotranspiration Index. Since 1986, bare ground has decreased from 75% to 59% inside the exclosure and 92% to 81% outside of the exclosure. Rooted frequency

of Hilaria rigida (big galleta) has decreased from 27% to 23% inside the exclosure and from 16% to 0% outside of the exclosure. Cover frequency of Larrea tridentata (creosote bush) has increased from 18% to 42% inside the exclosure and from 14% to 27% outside of the exclosure.

Long-term vegetation trend data such as this has been collected across Arizona through the Arizona Cooperative Rangeland Monitoring Program; a collaborative effort between the University of Arizona Cooperative Extension and the Bureau of Land Management. This program encourages extension personnel, agency staff and grazing permittees of the County to come together to monitor the range and participate in educational rangeland activities in order to better understand each other and the land with the goal of more sustainable management of Arizona's vital rangelands.

37. WITHIN SITE LOCATION AND SOIL CARBON:NITROGEN IN CENTRAL ARIZONA PINON-JUNIPER RANGELAND DIFFERING IN CANOPY COVER.

Douglas R. Tolleson*[1], Chris Bernau[2], Sue Smith[3], Lori Metz[4]; [1]Texas A&M University, Sonora, TX, [2]USDA-Natural Resources Conservation Service, Fallon, NV, [3]Private Consultant, Prescott, AZ, [4]USDA-NRCS Resource Assessment Division, Temple, TX

The objective of this study was to describe spatial variation (i.e. within interspace [I], as well as under perennial grass [G], deciduous shrub [S] and evergreen tree [E] canopy) in topsoil organic carbon (OC) and nitrogen (ON) of pinon-juniper rangeland differing in juniper (primarily *Juniperus monosperma* and *J. osteosperma*) canopy and understory vegetation. Nine macroplots (100m x100m) were established on sites characterized as phase I (31.3 ± 5.9 trees/ha), phase II (192.7 ± 107.4 trees/ha), or phase III (104.6 ± 31.9 trees/ha) juniper canopy. Predominant understory plant species were blue grama (*Boutelua gracilis*), western wheatgrass (*Agropyron smithii*), and sideoats grama (*B. curtipendula*) for phase I, broom snakeweed (*Gutierrezia sarothrae*), blue grama, and sideoats grama for phase II, and broom snakeweed, red sprangletop (*Leptochloa filiformis*), and whitemargin sandmat (*Euphorbia albomarginata*) for phase III. Above ground dry matter standing crop was 1413.2 ± 303.3 kg/ha, 478.3 ± 256.9 kg/ha, and 64.2 ± 28.7 kg/ha, for phase I, II, and III respectively. At each of the 9 macroplots, 3 soil samples (approximately 250g from top 2.5 cm) each were collected in I, G, S, and E. Samples were dried at 50C, milled to 2mm and OC and ON content was determined using a Teledyne-Tekmar Apollo 9000 C:N analyzer. Differences in OC and ON were determined by Anova. OC and ON ($P < 0.05$) were 239.35 ± 21.44, 20.06 ± 2.33; 279.09 ± 35.04, 18.39 ± 1.79; and 265.48 ± 35.22, 22.32 ± 2.14 for phase I, II, and III respectively. Similar values ($P < 0.05$) were 97.23 ± 5.66, 9.54 ± 0.69; 128.28 ± 7.38, 12.63 ± 0.62; 422.23 ± 36.38, 30.83 ± 2.50; and 397.48 ± 21.50, 28.03 ± 1.92 for I, G, S, and E respectively. Spatial distribution of topsoil OC and ON should be considered when comparing ecosystem sites.

38. INVASIVE ANNUAL GRASSES; IDENTIFYING INVASION MECHANISMS AND FINDING PRACTICAL, ECOLOGICALLY-BASED MANAGEMENT

SOLUTIONS. Merilynn Schantz*[1], Roger Sheley[2], Thomas A. Monaco[3]; [1]Miles Community College/Red Rock Resources LLC, Miles City, MT, [2]USDA-ARS, Burns, OR, [3]USDA ARS, Logan, UT

Annual grass invasions and ecological disturbances associated with energy development, drought, and wildfires can reduce ecosystem services throughout western US rangelands. Once dominant, annual grasses are self-sustaining because their litter provides substantial fuel for wildfires and they easily germinate following fire. Consequently, many areas invaded by these species have degraded to a point where perennial grasses will not reestablish without substantial inputs. There is a significant need to identify the mechanisms sustaining invasive annual grasses, determine perennial grasses that effectively establish in these regions, and discover management solutions for breaking this feedback cycle. Here we present the results of two studies where we first identified the role of seed dispersal timing and frequency, seeding rate, and water availability on the competition between invasive annual and native perennial grasses, then identified practical, ecologically-based management solutions for breaking the annual grass feedback cycle and restoring seeded perennial grasses to these degraded regions.

39. ZUMWALT PRAIRIE AND THE CHALLENGES OF ELK MANAGEMENT. John Williams*[1], Mark Porter[2]; [1]Oregon State University Extension Service, Enterprise, OR, [2]Oregon Department of Agriculture, Enterprise, OR

Zumwalt Prairie, located in Wallowa County Oregon, is a privately owned 120,000 acre bunchgrass prairie, used primarily for livestock grazing. It represents the southern half the Wildlife Chesnimnus Management Unit. During the 1990's 300-500 elk would utilize the Zumwalt Prairie portion of the Chesnimnus unit during summer and fall, then move to lower elevation canyons on the national forest for the winter.By 2015 elk populations had increased on the Zumwalt Prairie to 3,890.The majority of these elk now spend the entire year on the prairie causing damage to soils, vegetation and fences. As elk increased on the Zumwalt Prairie, elk numbers were stable to decreasing on the national forest portion of the unit, resulting in an overall increase in elk to 5,500 by 2012.The Chesnimnus unit target population is 3,500 with 2,800 on public land and 700 elk on private Zumwalt prairie.

As elk populations grew, so did landowner concern. The number of antlerless elk tags issued were not increasing, primarily because of limited access and trespassing complaints. Zumwalt area landowners formed a landowner group in 2008. This group coordinated efforts to increase hunter access, add hunting seasons and tags, haze elk toward public lands and secure funds for elk friendly fences and crossings. Oregon Department of Fish and Wildlife and landowners began working on implementing new antlerless elk hunting in 2009.Currently, there are 7 hunts for the Zumwalt Prairie portion of the Chesnimnus unit, 110 tags each; this is an increase from 1 hunt with 50 tags.Hunts begin in late August and run through mid-January.Additionally, damage antlerless elk tags are offered on dates when controlled hunts are not in progress. With landowners supplying access and ODFW establishing increased tags the number of elk on the Prairie

is beginning to be reduced.

40. ANNUAL RANGELAND WEED RESPONSE TO ADAPTIVE GRAZING MANAGEMENT IN A DROUGHT STRICKEN CALIFORNIA. Danny J. Eastburn*, Ken Tate, Leslie Roche; University of California, Davis, Davis, CA

The widespread invasion of California's Mediterranean-type annual rangelands has led to declines in the multiple benefits society derives from these landscapes. It is imperative to find successful strategies for managing weedy invasives in these complex socio-ecological systems while adapting to a changing climate—which is expected to bring increasing frequency, severity, and durations of drought. Our investigation focused on testing the response of *Taeniatherum caput-medusae,* pasture productivity and species richness to three stakeholder prescribed grazing management strategies: season long continuous, fall-spring with winter rest, and fall-spring targeted grazing. We deployed an extensive permanent grid of 4 plots per acre across three grassland pastures (~120 ac each) and three oak woodland pastures (~200 ac each). This allowed for spatial and classical analysis of treatment effects. We found a reduction in *T. caput-medusae* ranging from 15% to 25% across all treatments. Through a spatial analysis utilizing natural neighbor interpolation we found targeted grazing reduced and nearly eliminated *T. caput-medusae* dominated communities (defined as >50% cover). We also found available forage was greatest within the targeted grazing treatment pastures, which was potentially due to increased forage harvesting efficiencies. We have found the potential capacity to adapt to drought is greatest in the intensive rotational grazing treatment pastures. The results of this study will help land managers and producers in decision making for drought adaptation and invasive weed management.

41. A COLLABORATIVE GRAZING MONITORING PROGRAM FOR PUBLIC RANGELANDS. David F. Lile*[1], Laura K. Snell[2], Ken Tate[3], Neil K. McDougald[4], Leslie Roche[3]; [1]UC Cooperative Extension, Susanville, CA, [2]University of California, Alturas, CA, [3]University of California, Davis, Davis, CA, [4]UC Cooperative Extension, Madera, CA

Public land grazing provide an essential forage base for sustaining ranching in much of the west, but remains a controversial issue particularly in regards to impact on riparian ecosystems. Modern grazing management, including typically moderate livestock stocking rates and specific riparian grazing standards have been implemented to balance riparian conservation and livestock production objectives. Grazing monitoring programs are designed to help managers 1) assess the effectiveness of riparian conservation grazing strategies; 2) adapt grazing management to site specific conditions; and 3) demonstrate successful environmental outcomes to a concerned public. However, there have been short-comings of some monitoring programs including inconsistent effort depending on agency staffing at local levels, inconsistent monitoring methodologies, and a lack of communication between range staff, permittees, and other resource managers. The

cumulative effect, in some cases, has been a shortage of data to guide adaptive management or policy analysis. In this study we present preliminary results of a collaborative riparian grazing monitoring program involving the University, stakeholders, and the US Forest Service. Study sites have been established on six National Forests and 34 different grazing allotments in California. Fifty-six sites were established in 2015 and 24 additional sites were added in 2016 for a total of 80 sites currently enrolled. Annual grazing use monitoring sites were selected to meet 2 main criteria: 1) presence of long-term (over 10 years) meadow vegetation trend data; 2) sites are representative of grazed meadows at the Forest and allotment scale. We will report on interrelationships between various grazing utilization metrics and common grazing standards including herbaceous utilization, browsing of woody vegetation, streambank stubble height, streambank disturbance (trampling), and livestock fecal load density. We also report labor and other costs required for such a monitoring program. Implications for an efficient and credible collaborative grazing monitoring program will be discussed.

42. EFFECTS OF INVASIVE PLANT SPECIES ON NATIVE BEE COMMUNITIES IN THE SOUTHERN GREAT PLAINS. Kaitlin M. OBrien*[1], Kristen A. Baum[2], Tomyeanne Folts-Zettner[3], Robert Bennetts[4]; [1]Oklahoma State University, Boerne, TX, [2]Oklahoma State University, Stillwater, OK, [3]National Park Service, Johnson City, TX, [4]National Park Service, Trinidad, CO

The worldwide decline of native insect pollinators is of growing concern, as well as the decrease in populations of many flowering forbs. In the southern Great Plains region of the United States, grasslands are one of the most important habitats for providing resources to pollinators. Non-native and invasive plant species can alter grassland plant communities, although it is not clear how invasive plants affect native bee populations and communities. We evaluated native and invasive floral resource availability and the composition of the native bee community across a gradient of invasion levels for three common invasive plants in the southern Great Plains, including *Kochia scoparia*, *Salsola* spp., and *Convolvulus arvensis*. Study sites were located within four National Parks, with approximately 10 plots representing the gradient of invasion levels sampled at each park, for a total of 40 plots. Pan traps were used to assess the native bee community and both native and non-native plant species and cover classes were recorded for each plot. Regression models were used to evaluate how the bee community (richness and abundance) responds to invasive plant species cover, with a separate analysis performed for each invasive species, as well as a combination of *Kochia scoparia* and *Salsola* spp., which commonly occur together. Preliminary results suggest grasslands with no or low levels of invasive species support higher bee species abundance and richness. Plots with a higher density of *Kochia scoparia* showed reduced native bee abundance and richness. Responses to plots containing significant densities of *Salsola* spp., or *Convolvulus arvensis* are less clear. Possible factors contributing to the observed patterns could be the lack of floral resources from invasive plants (e.g., *Kochia scoparia*), which do not require insect pollination, and reduced abundance and diversity of native forbs. This study suggests that invasive plant species control is important for improving grassland habitat for wildlife, specifically native bees.

43. RESTORATION OF BRINE WATER IMPACTED SOILS USING HALOPHYTES AND SOIL DISTURBANCES IN WEST TEXAS. Kye R. Burris*, Cody B. Scott, James W. Ward, Corey J. Owens; Angelo State University, San Angelo, TX

Contamination from brine water drastically alters a soils structure, chemistry, and production capability. Results of brine impacts on a soil include complete plant mortality, lower infiltration rates, and a change in the amount of essential macro and micro nutrients available for plant growth. This study took place on a ranch located 14 km south of San Angelo, Texas, USA which contains a 14-acre "kill zone". A soil analysis and geophysical survey was conducted to determine salt concentrations and delineate the salt water plume. Six halophyte species were planted in each of five zones of contamination. The species planted included Inland Saltgrass (*Distichlis spicata*s), Alkali Sacaton (*Sporobolus airoides*), Common and Giant Bermudagrass (*Cynodon dactylon*), Giant Sacaton (*Sporobolus wrightii*), and Four-winged Saltbush (*Atriplex canescens*). At the initiation of the study, soil analysis showed an excess in both sodium and chloride levels with averages of 2500 mg/kg and 5500 mg/kg. In addition, soil compaction exceeded 300 psi at the surface. The 2015 planting results were deemed inconclusive as most of the plants died via drought or animal destruction. In the spring of 2016, ripping and furrowing were applied in each zone of contamination along with the six plant species. Plant mortality varied from 38% (Alkali Sacaton) to 80% (Inland Saltgrass). Both soil disturbances positively impacted plant establishment and plant height. Changes in soil compaction and soil salinity will also be discussed.

44. PRECONDITIONING PROCEDURES AND SUPPLEMENTATION TO INCREASE REDBERRY JUNIPER CONSUMPTION BY GOATS. Chris S. Miller*, Cody B. Scott, Corey J. Owens; Angelo State University, San Angelo, TX

Both Redberry (*Juniperus pinochotii*) and Ashe Juniper (*Juniperus ashei*) are readily invading Texas rangelands. Both species of juniper contain monoterpenoids, a class of terpenes that if consumed at a high enough amount can cause aversive postingestive feedback that limits feed intake. Livestock will consume some juniper (<10%) during the winter when other forage is limited. In previous studies, both goats and sheep were fed juniper at weaning, and subsequently increased intake of the plant. In each study, freshly weaned lambs and kids were placed in individual pens and fed juniper for 14 days. The results showed that both classes of livestock increased intake and readily accept juniper as a dietary component thereafter. Unfortunately, most livestock producers do not have the facilities or labor available to feed sheep or goats in individual pens. This study compared acceptance of juniper by goats in individual pens versus feeding in groups. In addition, ½ of all goats also received protein supplementation (37%) to determine if supplementation with a protein source consisting of amino acids that escape rumen degradation would further enhance juniper acceptance. Freshly weaned goats were placed

in individual pens or in groups of five and fed juniper daily for 14 days. Intake was monitored daily. After 14 days of feeding juniper, all goats were placed in individual pens and fed juniper for an addition 7 days and intake was compared among treatments (conditioned in individual pens vs. conditioned in groups of five). Goats fed juniper in groups accepted juniper faster than goats fed juniper in individual pens. Regardless of treatment, all goats increased intake daily. Supplementation did not affect acceptance of juniper as a dietary item. By the end of the study, there were no differences in intake regardless of treatment.

45. FIELD SKILLS TO CURTAIL UNKNOWN PLANTS AT NOVEL VEGETATION MONITORING LOCATIONS. Gene A. Fults*; USDA NRCS, Vancouver, WA

There is an old story about a Rangeland Management Specialist who spent 19 years focused on learning the flora of the local area. That vegetation specialist, like many of you, was relied upon and recognized for your plant identification skills. Then you are tasked to do a vegetation monitoring project 3 States away and in a totally different biome. What can you do to reduce the number of unknown plant foliar cover hits in the resulting vegetation database and still maintain your status as plant expert? The first thing to realize is that local experts should be saved for last resorts. And remember that they tire easily so keep the number you finally present to them to less than 15. Old plant reference books have some of the best morphological characteristics and site habitat descriptions even though the plant scientific names have changed. Herbariums will cost you money. Plant lists for possible matches can get expansive and time consuming to manage. Photos, plant presses, and other time saving skills are discussed. The main point is 'don't make it up!' An unknown plant is bad but you should strive to be honest.

46. ASSESSMENT, INVENTORY, AND MONITORING (AIM) AT THE GRAND STAIRCASE-ESCALANTE NATIONAL MONUMENT: CURRENT PROGRESS AND FUTURE EFFORTS. J. Kenneth Bradshaw*[1], W. Allan Bate[1], Sean L. Stewart[2], Kevin H. Miller[3]; [1]Bureau of Land Management, Kanab, UT, [2]Bureau of Land Management, Cannonville, UT, [3]Bureau of Land Management, Denver, CO

Grand Staircase-Escalante National Monument (GSENM), has been implementing the Bureau of Land Management's terrestrial Assessment, Inventory, and Monitoring (AIM) strategy for the past four years. The AIM strategy provides scientifically sound and technically defensible monitoring of multiple resource conditions to support management decision making. The AIM strategy uses the generalized random tessellation stratified (GRTS) sample design to generate random sample locations within the project area that are weighted by ecological stratum. The benefit of GRTS in long-term environmental surveys is spatially balanced sampling units that are weighted based the importance of the size of the stratum or the variance of the population parameter within the strata. For example, giving more weight to strata commonly used for grazing allows for more robust

statistical inference in those areas (i.e., better population and variance estimates within each stratum where grazing occurs). The AIM strategy uses a core set of methods to assess plant community composition and vegetation heights to estimate forage availability, and species richness and diversity; and canopy-gap measurements and soil stability ratings to assess site stability and resilience. In addition to inventorying the current ecological condition of the selected strata, these methods will also help to assess trends during the monitoring phase of the AIM strategy. AIM points have been inventoried using three different approaches to stratum selection over the past four years: (1) points stratified by ecological site descriptions (ESDs) within grazing allotments (2013); (2) points stratified by ESDs Monument-wide (2014-2015); and (3) points stratified using LANDFIRE Bio-physical Setting (BPS) Monument-wide (2016). To date, there have been 131 AIM points collected Monument-wide, with 476 points scheduled to be collected between 2017 and 2026 using the LANDFIRE BPS stratification to complete the initial AIM inventory proposed for the GSENM. Ecological site descriptions are common between all stratification methods and post-sampling stratification based on ESDs will be used to field verify ESDs based on strata.

47. EXPANDING THE INVASION OF NATAL GRASS (*MELINIS REPENS* WILLD.) IN THE STATE OF CHIHUAHUA, MEXICO. Carmelo Pinedo*[1], Alicia Melgoza-Castillo[2], Felix Flores[2], Alfredo Pinedo[2]; [1]Universidad Autonoma de Chihuahua, Chihuahua, Mexico, [2]Universidad Autónoma de Chihuahua, Chihuahua, Mexico

In the state of Chihuahua, Mexico, new records of the invasion of Natal grass (*Melinis repens*) have been detected. This expansion is affecting livestock production as well as several ecosystems services, such as biodiversity. The objective of this study was to develop a prediction model to simulate the Natal grass distribution. The model takes into account the environmental factors where this grass is established. A total of 169 location points of Natal grass and 27 environmental variables were used to calibrate and validate the model. The software MaxEnt, version 3.3.3k and the technique of Principal Components Analysis (PCA) were used. Nineteen climatic variables were retrieved from the Wordclim database and 8 physical variables from each location point were obtained from thematic maps of the state. The model was evaluated throughout the ROC curve under the AUC = 0.949. The PCA selected 12 climatic variables. Precipitation of the season was the variable with the highest contribution for the model. The climate of locations with high probability of occurrence for Natal grass is a temperate semi-dry. No preference for soil texture was detected for the species. Most of the presence of Natal grass was located in places with air temperatures between 30 and 34 °C. The potential distribution resulted towards the short grassland prairie dominated by *Bouteloua gracilis.* The actual distribution of Natal grass covers 161,322 ha and will potentially increase to 458,000 ha. The developed model could be used as a tool for the elaboration of control or management programs for Natal grass.

48. VARIABLES THAT INFLUENCE SURVIVORSHIP FOR THE ENDANGERED PIMA PINEAPPLE CACTUS (*CORYPHANTHA SCHEERI* VAR. *ROBUSTISPINA*) AFTER TRANSPLANT. Gerald M. Berthelette*[1], Jeffrey S. Fehmi[2]; [1]Graduate Student, Tucson, AZ, [2]University of Arizona, Tucson, AZ

There has been little research carried out which assesses the ability or inability of the Pima Pineapple Cactus (*Coryphantha scheeri* var. *robustispina*) to be transplanted successfully, and what a successful transplant entails. What little research has been done, experiments have demonstrated low-levels of survival, and determinate variables remain largely unknown. As a result, the U.S. Fish and Wildlife Service does not consider transplanting as a viable conservation measure. This study monitors a population of Pima Pineapple Cactus (PPC) transplanted in 2014 and distributed along a natural gas pipeline right-of-way southwest of Tucson, Arizona. Variables assessed during this study included the influence of supplemental watering, using soil vs. bare root transplant methods, and the number of times an individual was transplanted. Other available data sets from past transplant experiments were assessed based on the various transplant methodology and abiotic variables associated with each transplant location to determine which had more influence. We found the abiotic variables were more influential to survivorship than transplant methodology. A predictive model for transplant success using a Classification and Regression Tree (CART) analysis shows that slope aspect, and the amount of photosynthetically active radiation (PAR) received by each plant appears to most affect survivorship for transplanted PPC. Understanding which variables influence survival within transplanted PPC will allow further conservation measures to take place regarding this endangered species.

49. USING MULTISCALE DROUGHT INDEX PLOTS TO AID IN INTERPRETING CLIMATE/VEGETATION RELATIONSHIPS. Andrew S. Brischke*[1], Michael A. Crimmins[2]; [1]UA Cooperative Extension, Kingman, AZ, [2]The University of Arizona, Tucson, AZ

Drought is complex. Temporal accumulation, spatial heterogeneity and precipitation intensity are all extremely important and distinguish hydrological, environmental, agricultural and other types of drought throughout the arid Southwest. The suite of drought indices available is also numerous and it is often difficult to discern which index is most useful for tracking potential impacts on different vegetation communities. Multiscale Drought Index plots show all windows of temporal accumulation of precipitation expressed in standard deviations units which may aid in finding optimal timescales for investigating climate/vegetation relationships. MDI plots were used in conjunction with long-term vegetation monitoring data and stocking rate over a nearly 35-year period to determine whether climate or grazing contributed more to a shift in *B. gracilis* dominated grassland to an *E. Lehmanniana* dominated grassland, or an annual grass dominated landscape on the Crossed J Ranch in Southeastern AZ. It was determined that drought, at different temporal and intensity resolutions directly contributed to the change in the vegetation community. As more long-term vegetation data sets become available, MDI plots may aid in refining the vegetation/climate

relationship. Further recommendations may be made by pointing to specific subsets of indices and how to use them.

Symposium:
Rangeland Reclamation and Restoration: The Roles of Productive Re-Use and Conservation

ENERGY, RANGELAND RECLAMATION AND REGULATION: A TALE OF TWO INDUSTRIES. Ryan F. Limb*[1], Jay M. Volk[2], Kevin K. Sedivec[1]; [1]North Dakota State University, Fargo, ND, [2]BNI Energy, Center, ND

North American rangelands have a long history of energy exploration and extraction activities that require active reclamation to restore ecosystem properties and functions. Among all energy industries, early reclamation efforts were minimal or non-existent, leaving scars on the landscapes still present today. With increased awareness and demand and technologies, reclamation efforts and success have improved over time. However, not all reclamation efforts and success among energy industries has progresses at the same rate and a strong dichotomy exists between the oil and gas and surface coal industries. Largely as a result from public demand, Federal legislation, specifically the Surface Mining Control and Reclamation Act of 1977, regulates the surface coal industry to both ensure future mining activities are conducted in an environmental sound manner and to provide resources to reclaim abandoned mines. Individual states are required to develop and enforce reclamation standards appropriate for their region. While the outcomes are not perfect and improvements are continually necessary, more than 11,000 ha of coal-mine land has gone through the permitting and bond-release process in North Dakota with approximately 800 new hectares annually among four mines. In contrast, there are combined active and inactive oil and gas wells occupying almost 33,000 ha, 2,600 ha impacted by spills with an additional land dedicated to access roads, pipelines and storage facilities. Reclamation mitigation recommendations are being discussed and investigated. However, current reclamation efforts and standards are left to the discretion of individual companies and contractors with varying success. Without overarching standards to direct reclamation, similar to the coal industry, reclamation following oil and gas exploration and extraction will continue to be marginally successful.

APPLYING LANDSCAPE RELATIONSHIPS AND SOIL SUBSURFACE DATA TO RECLAMATION PLANNING AND IMPLEMENTATION. Mandy J. Williams*[1], Jake Powell[2]; [1]SWCA Environmental Consultants, Las Vegas, NV, [2]SWCA Environmental Consultants, Sheridan, WY

Successful revegetation of arid and semiarid rangelands of the western United States relies on careful planning to ensure that reclamation measures are well suited for site conditions. Although extreme temperatures and lack of rainfall may impede revegetation success, reclamation commonly fails when soil resource limitations go unidentified and unaddressed. By applying a soil-landscape perspective to reclamation, one can make important interpretations about soil surface and subsurface conditions that aid in reclamation planning and implementation. We present an approach to use USDA Soil

Survey data to: (1) quantify surface and subsurface soil resource availability, (2) identify soil features or conditions that could limit revegetation success, (3) apply landscape relationships to customize treatment plans, and (4) tie soils data to ecological sites to tailor seeding or planting methods. We further describe approaches for using landscape relationships to break down Order 3 soil survey data (which contain multiple soil types) into site-specific soil interpretations.

EVALUATION OF RECLAMATION AND REMEDIATION TECHNIQUES ASSOCIATED WITH OIL AND GAS PRODUCTION IN THE NORTHERN PLAINS. Kevin K. Sedivec*, Ryan F. Limb, Jack Norland, Aaron Daigh, Aaron Klostermeier, Paula Comeau; North Dakota State University, Fargo, ND

As energy development continues to grow, a need for better reclamation and remediation techniques surfaced to return lands back to a productive, sustainable system for agricultural uses and ecological function. The unprecedented, growth of the oil industry in North Plains has presented innumerable benefits, but also a few attendant challenges, particularly with spill remediation and land reclamation. Project objectives included 1) determining the effects of reclamation techniques on vegetation establishment and soil properties following energy extraction, and 2) determine the effects of remediation techniques on salt removal from the soil profile on brine contaminated lands. One study consisted of reclaiming a 128 km long 3.5 dm diameter natural gas pipeline and a 22.86 m wide pipeline right-of-way. The research design was a randomized block design with three plots per block and three blocks (replications). The pipeline corridor was seeded to a native mix using two seeding rates (TRT) at approximately 300 and 1500 (spiked) seeds per m2. The individual plots were 20-22 m x 6 m long providing trench, spoil, and travel sections to study and treated as a nested factor. The spike seeding resulted in higher basal cover than the normal seeding after one growing season. However, by the second growing season there was no difference in basal cover between the seeding rates, and basal cover was the same or higher than adjacent native grassland. There was no difference in planted or weed/exotic cover between normal seeding and the spike seeding in the different sections of the right of way: travel, trench or spoil. Because there was an even distribution of both the seedings and in the re-spread of topsoil, conditions created by the different right of way disturbances was not a factor. Spike seeding is effective in getting high levels of planted cover in the second growing season.

ACTIVE VERSUS PASSIVE REVEGETATION: PLANT COMMUNITY RESPONSE TO SEEDING, MULCH, AND SOIL AMENDMENTS IN ARIZONA. Jeffrey S. Fehmi*; University of Arizona, Tucson, AZ

For the successful reclamation of disturbed land, the reduction of initial erosion risk must be balanced with later vegetation establishment. This can be problematic in arid and semi-arid regions such as southern Arizona. Revegetation practices such as seeding with a diverse seed mix can result in greater native plant cover, species richness, and

herbaceous biomass than both the unseeded plots and the control plots. However after seeding, the resulting plant communities may be substantially different from the pre-disturbance communities or may fail altogether due to lack of rainfall. Undesirable species can also dominate unseeded plots. Surface mulches such as straw or wood chips can result in more vegetation establishment and above ground biomass while suppressing undesirable volunteer species and reducing erosion. As mulch amounts increase erosion decreases but, above a threshold, vegetation begins to decrease and is suppressed by surface applied mulch. Incorporating mulch into the soil can result in community composition shifts toward more grasses or suppress vegetation entirely but has a more ambiguous effect on erosion. Documented seeding and amendment practices were evaluated and put into a framework to evaluate their potential for success in terms of erosion control, resulting plant community, and potential of the reclaimed site for reuse.

THE INTEGRATION OF RANGE HEALTH ASSESSMENTS INTO RECLAMATION CRITERIA FOR OIL AND GAS DISTURBANCES ON ALBERTA RANGELANDS. Tracy A. Kupchenko*; Alberta Energy Regulator, Medicine Hat, AB

What happens to an oil/gas well when it "dies"?
Scientific research on rangeland management has been occurring in Alberta since the 1920's. The focus of this research was from a grazing perspective and has resulted in the creation of numerous tools and guidelines to measure and monitor range health.
The same tools and guidelines are being utilized by industry and environmental reclamation practitioners in Alberta when reclaiming upstream oil and gas disturbances on grasslands.
The life cycle of an oil or gas well is unique to its physical location and production history. Once an industrial licensee determines a well is not productive and/or operationally necessary, there is a process to follow to achieve regulatory "closure" of the site. In Alberta, this process is called the "2010 Reclamation Criteria for Wellsites and Associated Facilities for Native Grasslands" (ESRD). A simultaneous shift in principles has occurred – initially from reclamation of the site to equivalent land use, to current practices of restoration of the plant community at an industrial site.
This presentation will give a brief history of how and why the Alberta Range Health Assessment tool (Barry Adams et al) has evolved into a major component of the reclamation certification process as a result of this shift in desired outcomes.

A USER GUIDE TO ALBERTA GRASSLAND RECLAMATION CRITERIA. Darin E. Sherritt*; Tannas Conservation Services, St Albert, AB

Since the 1960's, reclamation of oil and gas facilities has been guided by provincial regulations within Alberta. The most recent reclamation criteria update, "The 2010 Reclamation Criteria for Wellsites and Associated facilities for Native Grasslands" was released in 2010 and was developed to provide an assessment criteria and methodology for reclamation within the grassland region of Alberta. The purpose of the 2010 Criteria

was to provide a science based assessment criteria to determine whether a site has met equivalent land capability that is clearly defined, statistically viable, and enforceable for non-compliance. The native grassland vegetation assessment utilizes similar concepts as the existing range health assessment techniques; however, the reclamation criteria requires more detailed data collection and addresses landscape, vegetation as well as soil parameters. This criteria compares the disturbed area to an adjacent offsite area within a similar plant community type and landscape position. The criteria is designed to be robust enough to be applied on virtually any site type and with the flexibility to adapt to anomalies. This presentation will provide a step by step walk through of the final reclamation assessment process in Alberta from desktop preparation to using the criteria on a reclaimed site, and how we interpret the results to determine if the site is on a trajectory towards meeting its potential for equivalent land capability.

RANGELAND MECHANICAL RIPPING AS INFORMED BY THE KEYLINE® DESIGN PROCESS IN EASTERN BUTTE COUNTY. Frank J. Thrall Jr.*; California State University, Chico, CA

The efficacy of rangeland mechanical ripping in southeastern Butte County when applied using the guidelines of the Keyline® design process is being tested over a five year period. Rangeland mechanical ripping is one of the conservation practices approved of by the USDA's Natural Resources Conservation Service. It is used to control erosion, increase forage production, increase water infiltration, and reduce compaction. The Keyline® design process was developed in Australia over 50 years ago and has a unique way of applying rangeland mechanical ripping techniques based on local topography. Proponents of Keyline® claim an increase in soil development, CO_2 sequestration, and water holding capacity in rangelands that are treated with Keyline® mechanical ripping. Scientific literature has supported mechanical ripping, among other mechanical rangeland treatments, as being beneficial. However, there is not any scientific literature that supports the claims made by proponents of the Keyline® process that it has any efficacy in improving the water holding capacity of rangeland soils, increases forage production, or leads to more soil organic matter. This research is recording changes in bulk density, soil moisture levels, forage quality and quantity, and soil organic carbon. If Keyline® is shown to be effective at increasing the water holding capacity of rangeland soils, it makes sense that rangelands may be more productive with greater amounts of forage. An increase in water holding capacity may have positive impacts on riparian areas and stream health. If rangeland compaction can be effectively remedied, there is a possibility of rehabilitating degraded rangelands and offering those interested in the restoration of endangered perennial grass species a cost-effective tool toward that goal.

RESTORING SEMI-ARID LANDS WITH SUPERABSORBENT POLYMERS UNDER REDUCED PRECIPITATION AND THREAT OF *BROMUS TECTORUM* INVASION. . Magda Garbowski*[1], Cynthia S. Brown[1], Danielle B.

Johnston[2]; [1]Colorado State University, Fort Collins, CO, [2]Colorado Division of Parks and Wildlife, Grand Junction, CO

Restoration of semi-arid lands in the western U. S. is hindered by invasion of exotic species such as *Bromus tectorum*(cheatgass) and highly variable weather. Decreasing soil moisture variability in may promote establishment of a native species over invasive species. With their ability to absorb moisture when it is abundant and slowly release it over time, superabsorbent polymers (SAP) may increase overall soil moisture and decrease soil moisture variability during restoration. In this study, we aimed to investigate the interactive effects of precipitation timing, drought, *B. tectorum,* and SAP on soil resources and developing restoration plant communities.

The study was established in 2014 at two sites in Colorado. Two levels of three treatments (drought: exclusion of 66% of ambient rainfall or ambient rainfall; *B. tectorum* presence: 465 seeds m-2 or none; SAP: 26 g m-2 or none) were fully crossed in three blocks at each site. After one year of monitoring, we observed significant effects of drought at both sites on soil moisture and plant communities. Independent and interactive effects of drought and SAP at the Eastern Slope site and drought and *B. tectorum* at the Western Slope site influenced plant communities and soil moisture. At the Eastern Slope site, drought limited seeded species recruitment late in the season and SAP improved seeded species establishment under ambient precipitation. At the Western Slope site, total seedling densities were lower under drought and native seedling densities were lower with *B. tectorum*. At the Western Slope site, *B. tectorum* under ambient precipitation had a stronger negative impact on soil moisture at 30 cm depth than drought treatments. Our results suggest that the effectiveness of SAPs is likely affected by antecedent soil moisture and precipitation patterns.

GREENSTRIPS: SPATIALLY STRATEGIC, HIGH-INPUT RESTORATION TO AVOID BROAD-SCALE FORAGE AND HABITAT LOSSES IN INVADED RANGELANDS. Lauren Porensky*[1], Elizabeth A. Leger[2], Barry L. Perryman[2]; [1]USDA-ARS, Fort Collins, CO, [2]University of Nevada, Reno, Reno, NV

Millions of hectares in western North America have been negatively impacted by cheatgrass invasion, which transforms high-diversity ecosystems providing many ecosystem services into low-diversity ecosystems providing few services. Cheatgrass can promote wildfire, and burned sites are highly susceptible to further invasion. Post-wildfire restoration generally involves spreading limited resources over extensive areas, and this approach often fails to meet restoration objectives. We investigated an alternative approach that may be able to weaken cheatgrass-fire feedbacks, protect remnant and restored sites, and reduce further invasion by focusing restoration resources in small, spatially strategic locations. We tested multiple methods for creating greenstrips (fuelbreaks made of native plants), subjected experimental greenstrips to targeted grazing treatments, and monitored seedling densities over two years. At a highly invaded Great Basin site, we found that seed rate, spatial planting arrangement (mixtures vs. monoculture strips), seed coating technologies, and grazing treatments had strong and

interactive effects on seedling densities. Plots planted with a doubled seed rate had 50% more seedlings than those planted with an average seed rate. Within high seed rate plots, mixed plantings had 40% more seedlings than monoculture strip plantings (33±4 seedlings per m2 in mixed, high rate plots). Ungrazed plots had 40% and 90% more seedlings than spring- and fall-grazed plots, respectively. However, results were primarily driven by one planted species (*Elymus trachycaulus*) which was both highly successful and susceptible to grazing. At a minimally invaded Colorado Plateau site, planted seedling densities were much lower (1-2 per m2) and planting techniques had weaker effects. Our experimental greenstrips are still too young to function as fuelbreaks, and the long-term effects of targeted grazing remain unclear. However, second-year results showcase methods for creating dense stands of native perennials at invaded sites, and emphasize that biotic resistance, grazing, species identity, and intraspecific competition can all influence restoration success.

APPLICATION OF THE BLM'S ASSESSMENT, INVENTORY, AND MONITORING STRATEGY FOR RECLAMATION AND RESTORATION MONITORING. Alexander Laurence-Traynor*[1], Jason W. Karl[2], Zoe Davidson[1], Jessa Davis[3]; [1]USDI-BLM, Santa Fe, NM, [2]USDA-ARS, Las Cruces, NM, [3]USDI-BLM, Boise, ID

Monitoring of reclamation or restoration activities ("restoration monitoring" for brevity) is a crucial step in adaptive management not only to judge effectiveness of a restoration action but also to build evidence for its overall efficacy and context in which it is appropriate. Restoration monitoring should be targeted to detect the desired effects (and anticipated side effects) of the action. However, there is great value in adopting consistent monitoring indicators and methods to facilitate the use of existing data, leverage data quality and management processes already in place, and gain the ability to view restoration activities in the context of larger landscape monitoring efforts. The Bureau of Land Management's (BLM) Assessment, Inventory, and Monitoring (AIM) program provides a strategy for monitoring the status and trend of BLM rangelands at multiple scales, report on the effectiveness of monitoring actions, and provide information necessary for BLM to implement adaptive management. The AIM strategy emphasizes a set of core indicators and methods and statistically-based sampling design to provide consistency and rigor to BLM monitoring. AIM is a flexible tool that can be applied to situations like restoration monitoring (e.g., via use of supplemental indicators) while retaining compatibility with larger scale monitoring efforts. There are several ways in which the AIM strategy or existing AIM data can be applied to restoration monitoring including: augmenting existing restoration monitoring; using in before-after-control-impact (BACI) sampling designs; comparing data from restoration sites to either nearby similar AIM sites or to a collection of AIM sites from the same land type; or comparison of restoration monitoring data to reference conditions developed from a larger collection of AIM data. We will illustrate each of these approaches through examples of where BLM has used AIM data for restoration monitoring in northwestern Colorado, northern New Mexico, and eastern Alaska.

Oral Technical Session:
Rangeland Ecology I

UNDERSTANDING AND ADAPTING TO EFFECTS OF CLIMATE CHANGE ON NATURAL RESOURCES IN THE INTERMOUNTAIN REGION. Matt C. Reeves*[1], Jessica Halofsky[2], David Peterson[3], Natalie Little[4]; [1]USDA Forest Service, Florence, MT, [2]University Of Washington, Seattle, WA, [3]Pacific Northwest Research Station, Seattle, WA, [4]USFS, Ogden, UT

The Intermountain Adaptation Partnership (IAP) recently completed a climate change vulnerability assessment for national forest lands in Utah, Nevada, southern Idaho, an area where a warmer climate is expected to significantly affect natural resources. The biggest near-term effects are projected for water resources and fisheries, which are responsive to declining snowpack and altered stream thermal habitat, respectively. Effects on vegetation and terrestrial wildlife are less certain and will probably be driven by increasing frequency and extent of disturbances. Increasing area burned will have a significant impact on mature sagebrush systems, reducing critical habitat for greater sage-grouse and other species. Some grassland systems may experience increased productivity, depending on local soils and precipitation trends, providing benefits for grazing by livestock and native ungulates. The IAP developed a wide range of strategic and on-the-ground adaptation options that can be implemented by federal land managers to minimize the negative effects of climate change and transition ecosystems to the new conditions expected in future decades.

BIOMASS CONSUMPTION AND THE FERTILIZER EFFECT OF DUNG DEPOSITED BY MIGRATORY NATIVE BISON IN YELLOWSTONE NATIONAL PARK. . Bill Hamilton*[1], Sydney Lundquist[1], Anna Alexander[1], Chris Geremia[2], Rick Wallen[2]; [1]Washington and Lee Univ, Lexington, VA, [2]National Park Service, Mammoth, WY

Yellowstone National Park is home to the largest population of free ranging genetically pure American bison (*Bison bison*). The current population estimate is 4,800 animals which utilize the parks grasslands throughout most of the year. In 2015, the National Park Service began an assessment of the effects of bison across the migratory range of both the Central and Northern Range herds that includes 23 field sites across the altitudinal migratory gradient. The effects of bison a population this size on grassland ecosystems has not been determined and in this study we present average consumption rates across the landscape and the contributions of plant available nutrients returned to soil by bison dung. To accomplish this each site has three fixed and five movable animal exclosures (moved every 4-6 weeks) that allow seasonal grazing consumption rates and plant available soil nutrients (nitrogen and phosphorous) to be quantified. Transects were used

to quantify dung inputs and a subset of sampling was done seasonally for total mass and dung nutrient analysis. Grazing consumption ranges from 10-70% across the migratory range and is correlated with the availability of soil moisture. Nitrogen inputs from dung ranged from 3-14 kg N/Ha and was closely correlated to consumption and altitude. Phosphorous inputs ranged from 0.8-3.5 kg P/Ha and were closely correlated with altitude and season. N and P content of dung varies seasonally with higher N and P in spring dung. These findings indicate that bison are removing a significant but spatially variable amount of grass biomass and returning a significant portion of the nutrients back to the system in the form of dung. This suggests that the fertilizer effect of bison dung contributes to the maintenance of productivity in Yellowstone grasslands.

MEASURING ECOSYSTEM SERVICES PROVIDED BY ADAPTIVE MANAGEMENT ON SOUTHWESTERN RANGELANDS. Natalya C. Robbins Sherman*, Laura López-Hoffman, George Ruyle, Aaron M. Lien, Kaitlin Libby; University of Arizona, Tucson, AZ

In the face of a changing climate, the two hundred million acres of public rangelands in the western United States must be managed sustainably, in partnership with ranchers, the primary users and stewards of these federal lands. Rangeland ecosystems, which cover 70% of the global land surface and provide a large portion of the world's food production, are important for carbon sequestration, and are vital to air and watershed health. To address the complications that climate change will present for rangeland science and management, in 2007 the Southwest Region of the U.S. Forest Service (USFS), under the authority of the National Environmental Policy Act (NEPA), mandated that ranchers grazing on public lands include adaptive management as a part of their allotment management plans. Adaptive management theory recognizes that rangelands are not static and thereby allows land managers to respond to unexpected environmental stressors, such as drought, by adjusting the intensity, season, and duration of grazing. The 2007 adaptive management rule is thought to be an improvement over prior, conventional practices, but its efficacy has not been scientifically tested. The purpose of this research is to evaluate the ability of the 2007 adaptive management rule to improve the provision of rangeland ecosystem services. Evaluation of the present question will involve ecosystem service assessments derived from both USFS region-wide monitoring data and ecological fieldwork of a smaller subset of ranches.

EPISODIC RECRUITMENT CAN DRIVE REGENERATION IN PERSISTENT QUAKING ASPEN: AN EASTERN UTAH CASE STUDY. Stanley G. Kitchen[1], Sherel K. Goodrich[2], Lara Kitchen*[3]; [1]US Forest Service, Provo, UT, [2]USDA Forest Service, Vernal, UT, [3]USFS, Dutch John, UT

Quaking aspen (*Populus tremuloides*; hereafter aspen) is the most widespread tree species in North America. In the American West, aspen regenerates primarily through vegetative suckers from roots. The importance of disturbance-driven pulsed regeneration

for stands seral to conifer is widely recognized. Less is known about recruitment periodicity for persistent aspen where conifers are largely absent. This study addresses the timing and vigor of regeneration response in eight persistent aspen stands located on the eastern Uinta Mountains. Study stands included adjacent areas that contrasted in canopy condition (intact vs depleted) and regeneration abundance (low vs high). Density was estimated for canopy trees, regen (stems < 2 m) and recruits (sub-canopy stems > 2 m) using paired plots in each stand. Cores were extracted from a subset of canopy trees and samples were cut from 5-15 regen and recruit stems at each plot for age and radial growth rate determination. Mean live tree density for high and low regeneration plots was 322 and 1426 trees/ha, respectively. Mean combined regen and recruit densities were significantly greater for depleted-canopy than for intact-canopy stands (13,164 vs 2461/ha), with a larger fraction in the taller recruit stage (56 % vs 3 %). Regen growth rate for depleted-canopy plots was significantly higher than that of intact-canopy plots suggesting a greater impact from tree competition than from high regen density. Canopy tree recruitment occurred primarily between 1873 and 1900 for six sites with a recruitment hiatus for all sites between 1920 and 1970. Recruit and regen ages revealed recruitment episodes in the 1970s and after the 2002 drought. The combination of greater abundance and faster growth rates for regen under depleted vs intact-canopies may be critical for successful recruitment suggesting a mechanism for disturbance-driven selection for pulsed-recruitment in persistent aspen that parallels processes observed for seral aspen stands.

PATHWAYS OF ASPEN RE-INITIATION AND PERSISTENCE ON THE ASHLEY NATIONAL FOREST. Allen A. Huber*, Sherel K. Goodrich; USDA Forest Service, Vernal, UT

Three modes of aspen regeneration are known to occur on the Ashley National Forest. Many stands, especially serial aspen, depend upon large-scale catastrophic disturbances to trigger new sprouting and maintain dominance on a site. Without fire and other catastrophic events, aspen decline in the western United States is expected and has been well documented.

Continuous regeneration is relatively uncommon mode of aspen regeneration. Stands with this capability are multi-tiered with continuous sprouting occurring underneath the mature tree canopy. On the Ashley National Forest, relatively few aspen stands with continuous regeneration have been observed, which leads us to believe that there are less stands with this capability than was documented in western Colorado (Kruzel et. al. 2007).

Episodic regeneration is found to be common in most persistent aspen stands. In the absence of fire and other catastrophic events, pulses of new sprouting following senescence has been repeatedly documented across the Ashley National Forest. Senescing aspen stands weaken or remove apical dominance, which typically stimulates root suckering.

In most aspen stands, apical dominance is the controlling factor in aspen sprout abundance and survival (Schier et al. 1985). Closed stands typically produce a few, inconspicuous sprouts each growing season, but these seldom survive to maturity. Such conditions persist until catastrophic disturbances or dieback during senescence remove or deplete aspen canopies. To expect numerous sprouts in all mature and vigorous stands is contrary to the apical dominance concept described by Schier (1985a).

AEROBIOLOGY AND PASSIVE RESTORATION OF BIOLOGICAL SOIL CRUSTS.

Steven D. Warren*[1], Larry St.Clair[2], Steven D. Leavitt[3]; [1]US Forest Service, Provo, UT, [2]Brigham Young University, Provo, UT, [3]Brigham Youn University, Provo, UT

Biological soil crusts result from intimate associations between soil particles and cyanobacteria, algae, lichens and/or bryophytes (mosses) living on and in the surface few millimeters of the soil. They are most common in arid and semi-arid areas. Biological crusts play important roles in primary productivity, nutrient cycling, hydrology, and soil stability. They are easily damaged by fire, off-road vehicles, livestock trampling, and surface mining. Depending on the nature of the disturbance, recovery times can be very lengthy. It may seem logical to attempt to accelerate biological crust recovery by inoculating disturbed sites with crust organisms. However, attempts to date have been largely unsuccessful and prohibitively expensive. The field of aerobiology may provide insight into natural, passive recovery processes. The field of aerobiology was developed for the purpose of identifying airborne algae, cyanobacteria, etc., that induce allergies and other medical issues. Aerobiologists have collected and subsequently identified numerous airborne organisms in the atmosphere. Only a very small percentage of the collected organisms, however, have been linked to medical issues. Yet, a large number of them are significant components of biological soil crusts. There have been few published links between airborne organisms and biological soil. Nevertheless, such airborne organisms seem to be essential for natural crust establishment and restoration following disturbance. The processes of aerosolization, transport and deposition are natural and widespread. There seem to be logical reasons that artificial restoration attempts have been largely unsuccessful, and why natural, passive mechanisms of airborne crust dispersal provide the answer.

ARBUSCULAR MYCORRHIZAL FUNGI IN WESTERN RANGELANDS: POTENTIAL SHIFTS IN SOIL FUNGI MAY IMPACT ECOSYSTEM RESILIENCE.

Matthew G. Hovland*[1], Ricardo Mata-Gonzalez[1], Paul Schreiner[2], Thomas J. Rodhouse[3]; [1]Oregon State University, Corvallis, OR, [2]USDA Agricultural Research Service, Corvallis, OR, [3]National Park Service, Bend, OR

Recent research suggests arbuscular mycorrhizal fungi (AMF) may play a large role in maintaining desired stable states in rangelands by increasing native plant community resilience to drought, grazing and exotic plant invasion. However, invasive plant species have been shown to alter AMF community composition in ways which may affect their

functionality and relationship with native plants. Climate change and the associated droughts, variable annual precipitation, altered fire regimes, and potential for exotic plant invasion has increased the importance of understanding the changes in AMF community structure and subsequent aboveground impacts in rangelands. Lasting soil legacies of negative feedbacks caused by invasive species may decrease the effectiveness of restoration actions at these sites, decreasing seedling establishment, soil moisture potential, and nutrient availability. We reviewed literature revealing the importance of AMF in rangelands, focusing on plant-fungal associations within the sagebrush-steppe community of the Great Basin and Intermountain West, and impacts on native AMF communities including land use, disturbance, and invasive species. We also sampled and analyzed roots of *Pseudoregneria spicata* and *Taeniatherum caput-medusae* within an invasion gradient in eastern Oregon. Our observations offer examples of an AMF colonized keystone bunchgrass competing with an exotic annual grass apparently lacking AMF association. The literature provides evidence that exotic plant invasion impacts on AMF community structure vary with plant species identity, and that effects range in severity from subtle to extreme. We suggest that more integrated and comprehensive studies of community, and individual species functionality within invaded and intact plant communities is needed to identify whether altered AMF communities are benefitting invasive species establishment, and if AMF community restoration is required prior to attempts to restore above ground communities.

BREEDING BIRD RESPONSES TO ROADS AND POWERLINES IN THE GRASSLANDS OF SOUTHEASTERN ALBERTA. Caroline Martin*, Scott Nielsen, Edward Bork; University of Alberta, Edmonton, AB

Linear disturbances in grassland systems, including powerlines, roads, and pipelines, have led to fragmented landscapes, soil degradation, and declines in sensitive species. Grassland birds, in particular, have undergone steep declines in populations due to the loss and degradation of grassland habitat. The construction of a major new transmission line in Southeastern Alberta in 2014 provides a unique opportunity to determine the direct effects of powerline construction on songbird species by comparing baseline pre-construction data from 2012 and 2013 to data from 2016 following transmission line development. 10-minute point counts were conducted across a 300m grid at Mattheis Ranch, located in Southeastern Alberta, during the breeding season of the summers of 2012, 2013, and 2016. 372 point count sites were sampled in 2012 and 2013, and a subset of these point counts were sampled in 2016 to focus on specific disturbances on the landscape and control areas without recent disturbances. Transects were blocked by treatment (road only, powerline only, road with powerlines on one side, road with powerlines on either side, and control). Other covariates, such as weather conditions during point counts, vegetation cover, grazing, range health scores, and ratings of visual obstruction were also collected. Species richness did not differ between treatments, but did increase with greater distance to linear disturbances. However, species-specific responses were more variable. Grasshopper sparrows demonstrated the greatest response to roads and powerlines, while other species, such as the Upland sandpiper and Clay-

colored sparrow, either increased near roads and powerlines or were not affected. Further analyses will look at how community structure changes with disturbance and comparisons will be made between years to evaluate the direct effect of powerline development in grassland habitats on songbirds, and what might be done to mitigate the effects of future transmission line developments on grassland songbirds.

LLAMAS AND CATTLE GRAZING EFFECTS ON RANGELAND HYDROLOGICAL FUNCTION. Teodoro B. Yalli, Javier A. Naupari, Enrique R. Flores*; Universidad Nacional Agraria La Molina, Lima, Peru

A study was conducted to assess the hypothesis that llamas (L) grazing effects on soil infiltration rate and soil moisture are lower than cattle (C) grazing because llamas have a lower impact on key soil and vegetation variables associated to rangeland hydrological function. Two ecological sites were selected, one dominated by *Festuca humilior* and *Carex ecuadorica (Fehu-Caec)* in regular condition (RS), and the other dominated by *Calamagrostis macrophylla* and *Stipa brachiphylla (Cama-Stibra)* in poor condition (PS), both sites managed under high intensity rotational deferred grazing system. Changes in biomass, litter, soil bulk density, soil infiltration rate, and soil moisture were assessed. Measurements were taken at the end of the deferment period and after each grazing period. The results revealed that in both sites (RS and PS) soil compaction was higher with cattle than with llamas (0.88 g · cc-1 vs. 0.86 g · cc-1, $p < 0.01$). There was no difference ($p > 0.05$) in infiltration rate (L, PS: 0.14 and RS: 0.18 cm · min-1) vs. (C, PS: 0.06 and RS: 0.17 cm · min-1) despite the fact that llamas grazing was more beneficial. Soil moisture, a key variable, was higher under llama grazing than with cattle ($p < 0.01$) (L, 29 % vs. C, 26 %), an outcome that was attributed to the higher amount of residual biomass that llamas left after grazing compared to cattle because eat less per unit weight than cattle. We conclude that American Camelids have lower impact on rangeland hydrological function than cattle do.

SWAINSONINE IN SELECT NORTH AMERICAN *ASTRAGALUS* SPECIES IMPLICATING A MORPHOLOGICAL AND PHYLOGENETIC SIGNATURE. Daniel Cook*[1], Dale Gardner[2], Jim Pfister[2], Stephen Lee[1], Kevin Welch[2]; [1]USDA ARS, Logan, UT, [2]USDA-ARS, Logan, UT

The indolizidine alkaloid swainsonine is an α-mannosidase and mannosidase II inhibitor that causes lysosomal storage disease and alters glycoprotein processing. Swainsonine is found in a number of plant species worldwide, and causes severe toxicosis in livestock grazing these plants, leading to a chronic wasting condition characterized by weight loss, depression, altered behavior, decreased libido, infertility, and death. Swainsonine has been detected in 13 North American *Astragalus* species of which eight belong to taxa in four taxonomic sections, the *Densifolii*, *Diphysi*, *Inflati*, and *Trichopodi*. These sections belong to two larger groups representing several morphologically related species, the

Pacific Piptolobi and the small flowered Piptolobi. We hypothesized that there may be a morphological and/or phylogenetic signature for swainsonine-containing species. The objective of this study was to screen the other 31 species for swainsonine in sections *Densifolii*, *Diphysi*, *Inflati*, and *Trichopodi* previously not known to contain swainsonine. Furthermore, to broaden the scope further, 21 species within the 8 sections of the Pacific Piptolobi and the small flowered Piptolobi were screened for swainsonine. A systematic examination for swainsonine in these species will provide important information on the toxic risk of these species and would be a valuable reference for land managers.

Symposium:
Rangeland Health Assessments: Technology, Use, and Status on U.S. Rangelands

STATUS AND UPDATES TO INTERPRETING INDICATORS OF RANGELAND HEALTH. Mike L. Pellant*[1], David A. Pyke[2], Jeffrey Herrick[3], Pat L. Shaver[4], Fee Busby[5], Gregg Riegel[6], Nika Lepak[7], Beth A. Newingham[8], Emily Kachergis[9], David Toledo[10]; [1]BLM, Boise, ID, [2]U.S. Geological Survey, Corvallis, OR, [3]USDA-ARS, Las Cruces, NM, [4]none, Monmouth, OR, [5]Utah State University, Logan, UT, [6]United States Forest Service, Bend, OR, [7]Bureau of Land Management, Boise, ID, [8]USDA-ARS, Reno, NV, [9]Bureau of Land Management, Denver, ID, [10]USDA-ARS, Bismarck, ND

Development of the widely applied rangeland health protocol, "*Interpreting Indicators of Rangeland Health*" (IIRH) was stimulated by the publication of the National Research Council's 1994 publication, *Rangeland Health: New Methods to Classify, Inventory, and Monitor Rangelands.* In a parallel effort, the Society for Rangeland Management's committee on *Unity in Concepts and Terminology* recommended that rangeland assessments should focus on the maintenance of soil integrity. Since then an interagency team from the BLM, NRCS, ARS, USGS, academia (Utah State University) and more recently the USFS have worked together to incorporate and revise IIRH. This protocol uses a combination of observable and measurable indicators to interpret and assess rangeland health. Published interagency technical references were updated in 2000 (Version 3) and 2005 (Version 4). Changes for the 2017 edition (Version 5) are in response to input from a large number of users of Versions 3 and 4 and are designed to improve the consistency of the application and interpretations made from the protocol. The indicators and attributes in Versions 3, 4 and 5 are essentially unchanged providing a consistent foundation for applying this protocol. A key clarification in Version 5 is that the reference sheet is based on the natural range of variability associated with the natural disturbance regime within the reference state, not the entire reference state. A Reference Sheet Checklist has been included to assist reference sheet developers or modifiers better describe the status and range of natural variability for each indicator in the Reference Sheet. Some indicator names and their associated narratives have been slightly modified and the approach to assess the Functional/Structure Groups indicator has been clarified to

improve user application. A Version 5 draft will be circulated for review and field testing in 2017 with a goal to finalize and publish Version 5 in early 2018.

MISSING LINKS AND FUTURE TECHNOLOGIES IN ASSESSING RANGELAND HEALTH. David A. Pyke*[1], Jason W. Karl[2], Jeffrey Herrick[2]; [1]U.S. Geological Survey, Corvallis, OR, [2]USDA-ARS, Las Cruces, NM

Rangeland health assessments, whether quantitative monitoring or qualitative assessments, may be conducted at several scales. As with any monitoring technique, rangeland health monitoring and assessment techniques require appropriate training and regular quality control and assurances among people collecting data. Core indicators for rangeland health monitoring may address most objectives and they may relate equally well across multiple scales provided criteria relating to stratification and randomization are applied. However, additional indicators that were unforeseen when monitoring began may be added to address potential management concerns assuming they meet the same criteria. Regional evaluations of the effectiveness of management treatments are rarely conducted, but periodic evaluations of multiple treatments conducted in a similar manner may provide managers useful information for adaptive management to improve the effectiveness of treatments in achieving rangeland health goals. Monitoring objectives of indicators for rangeland health are most often addressed at the site scale, but some resource management objectives, for example Greater Sage-grouse habitat, and their associated monitoring may require indicators that are meaningful at broader scales and may require remote-sensing platforms to track over scales that are meaningful for the organism. Sharing or combining data among different land ownerships or across administrative boundaries creates another barrier for managing rangeland health issues. Common protocols for collecting data, including the selected variables and how they are sampled among the different land ownerships may ease or restrict the ability to provide meaningful monitoring results. We will suggest a set of procedures to aid the evaluation of current protocols and a collaborative decision process for implementing future protocols. Tools such as structured decision making may aid in this process by providing documentation on how diverse groups make choices for complex decisions requiring a collaborative approach.

STATE AND TRANSITION MODEL FUNDAMENTALS: KNOW THE SUBJECT MATTER. Tamzen K. Stringham*; University of Nevada, Reno, Reno, NV

A state and transition model (STM) depicts our current understanding of ecological dynamics on an ecological site. An STM identifies the different plant communities or "states" that may exist on a given ecological site and how other site characteristics, such as hydrology and dynamic soil properties, might change as the plant community phase or state changes. STMs have the flexibility to describe both succession driven plant community dynamics and non-linear dynamics typically associated with chronic or catastrophic disturbances. STMs describe the environmental conditions, disturbances and

management actions that cause vegetation to change from one suite of plant species to a different suite of species, and the management actions needed to restore plant communities to a desired composition. The complexity of STMs has developed with maturation of the science and development of the models. Typically STMs are associated with ecological site descriptions (ESDs) however in the western United States many landscape-scale management issues such as fuel reduction treatments or post-fire rehabilitation activities occur at scales far larger than the individual ecological site scale therefore methods for aggregating ecological sites into groups that respond similarly to the same disturbances have been developed. Disturbance Response Groups (DRGs) consisting of multiple ecological sites with one generalized STM provides an ecologically sound landscape scale management tool for multiple applications including habitat restoration, fuels management, fire rehabilitation and grazing management planning.

THE RANGELAND MANAGEMENT AND SOIL HEALTH CONNECTION. Joel R. Brown*[1], Jeffrey E. Herrick[2]; [1]USDA-NRCS, Las Cruces, NM, [2]USDA ARS, Las Cruces, NM

Soil health is defined as the capacity of soil to function and provide ecosystem services to society. The importance of managing for the improvement and maintenance of soil health transcends political boundaries, generations, societies and languages. The challenge of communicating soil health concepts and motivating action lies in the incredible complexity of soil types, land uses, management practices and ecosystem services. Developing and implementing a successful institutional soil health effort requires credible approaches to determine baseline conditions, accurately measure change over management-relevant time, identify threats and establish relationships to human and natural drivers. While soil health indicators are a valuable addition to the assessment of rangelands, they are merely one of several necessary attributes required to develop a true picture. Developing and applying indicators of soil health (or any indicator) on rangelands is entirely *context dependent*. That context is provided by Ecological Sites and is organized, interpreted and communicated via Ecological Site Descriptions (particularly State and Transition Models). This approach will allow us to develop a protocol for the site specific assessment of the economic value of soil health improvement.

CONDUCTING RANGELAND HEALTH ASSESSMENTS IN THE FIELD. Pat L. Shaver*; none, Monmouth, OR

Rangeland Health assessments follow a five-step process to evaluate the degree of departure from reference conditions for the three Rangeland Health attributes. Before field operations to conduct assessments begin, there are several activities that must be considered to ensure good, accurate and useful assessments are obtained. Selecting

evaluation locations is often one of the most difficult aspects of conducting the assessment. Evaluation areas need to be large enough to show some variability within the ecological site being assessed, but small enough to see and move around in easily. Locations may be stratified into ecological sites or groups of ecological sites, may be completely random, or selected to sample specific conditions. Each of these methods of selection may be appropriate depending on the reason for making the evaluation. After the evaluation areas are selected, maps, soils information, ecological site descriptions, reference sheets and available inventory and monitoring data may be assembled. This information and data is useful to organize tools, and needed support items as well as providing information about what to expect on site. Once in the field, a determination of the ecological site is necessary to ensure proper reference sheets are used. Supplementary information including the identification and organization of existing vegetation into functional/structural groups and determination of the relative dominance of each group should then be done. Other data may be collected to aid in the evaluation of the indicators such as percentages of bare ground and litter cover, soil stability ratings, etc. After all additional information and data is collected, the 17 indicators are evaluated against the information on the reference sheet. Notes are recorded explaining indicator ratings and the indicators summarized into the appropriate attributes. Attribute ratings are made using a preponderance of evidence approach and notes are recorded to explain final attribute ratings.

ADAPTING FIELD RANGELAND HEALTH ASSESSMENTS TO CONSERVATION MANAGEMENT PLANS. Patti J. Novak-Echenique*; USDA-NRCS, Reno, NV
The conservation planning process developed by the USDA-Natural Resources Conservation Service consists of nine steps divided into three phases: 1) collection and analysis, 2) decision support, and 3) implementation and evaluation of the plan. A rangeland health assessment is a planning tool that is used during all phases of the planning process. Ecological sites are inventoried and assessed with the associated rangeland health reference sheet developed for each ecological site. The attribute ratings for soil/site stability, hydrologic function, and biotic integrity, are compared to the assessment level of the planning criteria for the specific plant or soil resource concerns that have been identified. The individual rangeland health indicators are used to identify which ecological sites may be approaching an ecological threshold. The individual indicator and attribute ratings are then used to select conservation practices that address the resource concerns identified in the inventory. Follow-up rangeland health assessments can be used to determine the effectiveness of the conservation plan and associated practices and to make additional adjustments to the conservation plan.

USE OF RANGELAND HEALTH ASSESSMENTS AT THE RANCH LEVEL. David J. Kraft*; USDA/NRCS, Emporia, KS

Throughout the history of the Soil Conservation Service and now the Natural Resources Conservation Service, conservation planners have used trend determinations, species composition, range condition, and similarity index, to assess, communicate, and prepare decision maker's to ultimately select management practices or techniques for land they managed and management goals they had identified. While these assessment tools, protocols, and methods have been successful through time, they were in some ways incomplete in fully addressing all indicators visually observed on the landscape. Producers were ultimately needing additional information to make sound and responsible decisions to encourage landscape and plant community change towards an identified management goal. To address this need, NRCS conservation planners in Kansas, began a process of exposing ranchers and land managers to Rangeland Health and its seventeen indicators and three attributes. This process first began through two adult oriented range schools hosted by the Kansas Grazing Lands Coalition. During the three day schools, presentations and field demonstrations highlighted the data collection, analysis, and assessment of site specific information used to evaluate "Rangeland Health". This process highlighted an awareness between both planner and operator and the importance of being able to identify and communicate observations and data from the rangeland resource which both cared so passionately about.

Today conservation planners and producers alike, go beyond the casual observation and conversation of species composition, trend, and similarity index, and dig deeper into how sites function in optimum condition and departures away from optimum. This one on one process and communication starts with a more complete understanding of soils, ecological sites, plant communities, and how they are supposed to function, to a relationship between conservationist and land manager and their adaptations to increased knowledge of their rangeland resource.

RANGELAND HEALTH ON US RANGELANDS. Veronica C. Lessard*; USDA-NRCS-Resource Inventory Division, Ames, IA

The US Department of Agriculture Natural Resources Conservation Service (USDA-NRCS) conducts the National Resources Inventory (NRI) to monitor the conditions and trends of soil, water, and related resources. The NRI program collects annual on-site data on a subset of its monitoring sites located on non-Federal rangeland to obtain more detailed information about those lands. Rangeland health assessments are among the standard indicators and methods conducted. These assessments are supported by additional indicators including presence and prevalence of invasive plants, bare ground and bare ground within canopy gaps that often provide opportunity for erosion and replacement of native plants with non-native species, and soil aggregate stability ratings that are indicators of soil quality, soil organic matter content, biological activity, and ability to resist erosion. Status and change in these indicators are evaluated with data collected between 2004-2010 and 2011-2015.

DOCUMENTING OUR KNOWLEDGE OF RANGELAND HEALTH ON RANGLANDS. Curtis J. Talbot*; USDA-NRCS, Las Cruces, NM

Documentation of rangeland health comprises two primary parts. First, there is the need to establish the standard. This has been established as the rangeland health reference sheet, and is a description of proper ecological functioning within a normal range of variation. As mentioned earlier in the symposium, this standard is divided into 17 indicators that are then combined to qualitatively describe the attributes of the three attributes of soil/site stability, hydrologic function, and integrity of the biotic community. Second, there is the need to document the inventory of existing rangeland health specific to a particular point on the earth and a particular point in time. These point data are then compared against the standard, or reference sheet, to determine the degree of departure. It is logical to assume that a national database of both parts is needed. Currently the rangeland health reference sheet is stored in the Ecological Site Information System (ESIS). ESIS is no longer actively supported by NRCS and has lacked programming support for a number of years. Efforts are underway to establish a new database to house ecological information and this may be a possible home for the rangeland health reference sheet. There is currently no accepted central repository for rangeland health inventories. The National Soil Information System (NASIS) has been tentatively identified as a repository for these records, but has not been widely adopted. The uncertain standing of these databases offers up a unique opportunity to describe the business requirements of rangeland health documentation, and either identify an existing database or build a new database to meet current and future needs.

Oral Technical Session:
Rangeland Ecology II

RANGELAND RESILIENCE AND RESISTANCE: ANNUAL AND PERENNIAL GRASS STABLE STATES. Dan Harmon*, Charlie D. Clements, Robert Blank; USDA-ARS, Reno, NV

The concept of resilience – the ability to resist a shift to an alternative vegetation state - has become an important topic in range management. To quantify the degree to which a plant community is resilient, we experimentally manipulated communities dominated by either the invasive annual grass cheatgrass (*Bromus tectorum*) or a perennial grass. We hypothesized that an interaction between soil moisture and seed availability controls resilience in these communities. To test resilience, we controlled cheatgrass and at separate sites removed perennial grass using herbicides and measured establishment of the alternate vegetation state. We seeded 322 perennial grass seeds/m2 and 1076 cheatgrass seeds/m2 into their alternate state (annual grass dominant and perennial grass dominant respectively). Removal of the annual grass resulted in an increase of soil moisture (June gravimetric mean: 15cm depth removal 4.91%, non-removal 2.69%, 3cm depth removal 1.7%, non-removal 0.3%) and subsequent shift to perennial grass state after seeding. Without annual grass removal, perennial grass seeding failed to establish. Removal of the perennial grass resulted in a two fold increase in annual grass

(mean: removal 42 cheatgrass/m2, non-removal 20.45 cheatgrass/m2), however small sample sizes limited detection of soil moisture differences. These results indicate a less resilient stable state for perennial grass than annual grass dominated states, since cheatgrass was able to establish in the presence of perennial grass when it was seeded (20.45 cheatgrass/m2). Our results support the hypothesis that soil moisture is the direct threshold maintaining annual grass stable states and that annual plant presence or absence is the indirect threshold limiting soil moisture and the shift to an alternate state. For perennial states, a combination of perennial presence and annual seed abundance interact to limit alternate states. We conclude that density of the dominant vegetation is an acceptable indicator of the resilience of these two stable states.

RANGE MANAGEMENT AND CLIMATE ADAPTATION: QUANTITATIVELY DECIDING HOW TO LET THE CHIPS FALL. Amy J. Symstad*[1], Brian W. Miller[2], Leonardo Frid[3], Nicholas A. Fisichelli[4], Gregor W. Schuurman[5]; [1]U.S. Geological Survey, Hot Springs, SD, [2]DOI North Central Climate Science Center, Fort Collins, CO, [3]Apex Resource Management Solutions Ltd., Ottawa, ON, [4]Schoodic Institute at Acadia National Park, Winter Harbor, ME, [5]National Park Service, Fort Collins, CO

Effective range management requires long-term planning, but in this era of unprecedented climate change, multiple uncertainties increase the challenges associated with such planning. Scenario planning (SP) is one tool to deal with these uncertainties because it guides managers through a process of examining their management practice options under a range of divergent and challenging, yet plausible, story lines. However, SP may lack the quantitative comparisons and scientific process needed by public land management agencies to support their decision-making. We used an iterative approach for combining quantitative ecological modeling with qualitative, participatory SP in a southwest South Dakota study area. This approach included a series of workshops with resource managers to identify key resources, impacts, and uncertainties under four climate change scenarios. In the workshops, managers qualitatively explored the interacting effects of grazing, fire, climate, and invasive species on vegetation condition and key animal species. Using the information on interacting influences garnered from these workshops and beginning with the conceptual state-and-transition models and productivity information in ecological site descriptions for dominant soil types in the study area, we developed a state-and-transition simulation model of vegetation dynamics. We used the model to explore the effects of four general management approaches under the four climate scenarios. In the qualitative SP workshops, managers imagined the need to reduce stocking rates under hotter and drier conditions, and they expressed concerns about invasive plants in wetter conditions. Key results from the modeling exercise, however, suggest that conservative stocking rates maintained by the national park in the study area may adversely affect vegetation composition in any climate scenario. Results also illustrate potential problems (e.g., lack of forage, increase of undesirable vegetation states) that may arise when management practices designed for one climate projection are implemented under different climate conditions.

PREDICTING CLIMATE CHANGE IMPACTS ON SAGEBRUSH POPULATIONS: MODEL COMPARISON GIVES REASON FOR HOPE. Peter B. Adler*[1], Katie Renwick[2], Caroline Curtis[3], Andrew R. Kleinhesselink[1], Daniel Schlaepfer[4], Cameron Aldridge[5], Bethany Bradley[3], Ben Poulter[6]; [1]Utah State University, Logan, UT, [2]Montana State University, Bozeman, MT, [3]University of Massachusetts, Amherst, MA, [4]University of Basel, Basel, Switzerland, [5]CSU, USGS, Fort Collins, CO, [6]NASA, Greenbelt, MD

Healthy big sagebrush habitat is essential for the persistence of many high value conservation species across the Western U.S. To gain confidence in predictions of climate change impacts on existing populations of big sagebrush, we compared output from four modeling approaches, each based on different data and assumptions. The models consistently predicted that rising temperatures will decrease sagebrush cover and biomass only in the warmest portions of the region, but will have neutral or even positive effects on sagebrush across much of its current distribution. All locations where our models agree on negative impacts fall within areas classified as having low resistance and resilience to plant invasions and fire. These results indicate that climate change will not undermine investments in sagebrush conservation and restoration except in the warmest and least resilient portions of the region. An important caveat is that our models do not consider how climate change will interact with the invasive grass-fire cycle, which is a high priority for future research.

EFFECTS OF CLIMATE PATTERNS ON SAGEBRUSH STEPPE ECOSYSTEMS IN SOUTHERN IDAHO OVER THE LAST 80 YEARS. Holly E. Cunningham*[1], April Hulet[2], Amanda Gearhart[3], Kirk W. Davies[4]; [1]University of Idaho, Eden, ID, [2]University of Idaho, Moscow, ID, [3]USDA-Agricultural Research Service, Burns, OR, [4]USDA - Agricultural Research Service, Burns, OR

Climate patterns can provide missing details and information related to historical and present day vegetation variation. However, there is a critical gap in the body of literature involving long-term changes in plant communities; particularly relative to climate and the effects climate has on secondary succession. The environment is competitive between invasive annual grasses and native perennial species in the sagebrush steppe ecosystem; especially after fire or other disturbances occur. This study was conducted on two exclosures located in southern Idaho that were previously tilled for farming, but abandoned in the early 1930's. Each exclosure is 8 ha in size, and has had minimal human influence in the past eighty years. Species density data were collected 1933-1949, 1992, 2015, and converted to functional groups (perennial bunchgrasses, annual grasses, perennial forbs, annual forbs, and perennial shrubs) for the data analysis. A repeated measures ANOVA was then used to evaluate plant community change overtime. Climate data (precipitation and temperature), extracted from the PRISM database was used as an explanatory variable. Preliminary results suggest that increased temperatures favored annual grasses and increased precipitation patterns favored perennial grasses. Long term datasets that evaluate plant community composition relative to climate patterns will increase our understanding of how climate influences secondary succession in sagebrush

steppe ecosystems. It can also prove to be of value to land managers in making vegetation management decisions as climate patterns continue to change.

MODERATE PATCHINESS OPTIMIZES HETEROGENEITY, STABILITY, AND BETA DIVERSITY IN MESIC GRASSLAND. Devan A. McGranahan*[1], Torre J. Hovick[1], R. Dwayne Elmore[2], Dave Engle[2], Sam Fuhlendorf[2]; [1]North Dakota State University, Fargo, ND, [2]Oklahoma State University, Stillwater, OK

Heterogeneity is fundamental to rangeland conservation because spatially and temporally-heterogeneous disturbance creates patchy vegetation and increase compositional dissimilarity. Ecological theory links compositional dissimilarity with beta diversity, but while heterogeneity has been associated with diversity-stability mechanisms, linkages between beta diversity and heterogeneity or stability have not been established. Meanwhile, questions about application remain: How many patches are sufficient to create spatial heterogeneity and reduce temporal variability? How frequently should patches burn? Does season of fire matter? To bring theory into applied practice, we studied a gradient of tallgrass prairie landscapes created by different sizes, seasons, and frequencies of fire, and used analyses sensitive to non-linear trends. Optimal heterogeneity, variability, and beta diversity occurred in landscapes with 3-4 patches and 3-4-year fire return intervals. Beta diversity had a positive association with spatial heterogeneity and negative relationship with temporal variability. Rather than prescribe that these results constitute best management practices, we emphasize the flexibility offered by interactions between patch number and fire frequency for matching rangeland productivity and offtake to specific management goals. As we saw no differences across season of fire, we recommend future research focus on fire frequency within a moderate number of patches and consider a wider seasonal burn window.

EFFECTS OF ELEVATED CO2 ON THE SWAINSONINE CHEMOTYPES OF *ASTRAGALUS LENTIGINOSUS* AND *ASTRAGALUS MOLLISSIMUS*. Daniel Cook*[1], Dale Gardner[2], Jim Pfister[2], Daniel LeCain[3], Clint Stonecipher[2], Joseph G. Robins[1], Jack Morgan[3]; [1]USDA ARS, Logan, UT, [2]USDA-ARS, Logan, UT, [3]USDA ARS, Fort Collins, CO

Rapid changes in the Earth's atmosphere and climate associated with human activity can have significant impacts on agricultural and livestock production. CO_2 concentrations, representing one of many atmospheric changes, have risen from the industrial revolution to the current time, and are expected to continue to rise. Climatic changes have been shown to alter physiological processes, and growth and development in numerous plant species, thus potentially changing concentrations of plant secondary compounds.   These physiological changes may influence plant population density, growth, fitness, and toxin concentrations and thus influence the risk of toxic plants to grazing livestock. Locoweeds, swainsonine containing *Astragalus* species, are one potential group of plants that may be influenced by climate change. We evaluated how two different swainsonine-containing *Astragalus* species responded to elevated CO_2 concentrations. Measurements of biomass, crude protein, water soluble carbohydrates and

swainsonine concentrations were measured in the two respective chemotypes (i.e., positive and negative for swainsonine) of each species at near present-day ambient and elevated CO_2. Biomass and water soluble carbohydrate concentrations responded positively while crude protein concentrations responded negatively to elevated CO_2 in the two species. Swainsonine concentrations were variable in response to elevated CO_2 in the two species. In the different chemotypes, biomass responded negatively and crude protein concentrations responded positively in the swainsonine-positive plants compared to the swainsonine-negative plants. Ultimately, changes in CO_2 and endophyte status will likely alter multiple physiological responses in toxic plants such as locoweed, however it is difficult to predict how these changes will impact plant herbivore interactions.

IMPACT OF THE CONSERVATION RESERVE PROGRAM ON LANDSCAPE PATTERNS. Evan P. Tanner*, Sam Fuhlendorf; Oklahoma State University, Stillwater, OK

Human culture and policy play an important role in structuring landscape patterns. Agriculture is an example of a land use practice that has altered landscape patterns worldwide and agricultural intensification coupled with broad patterns in land use change have resulted in decreased cover of native plant communities and a loss in biodiversity. The Conservation Reserve Program (CRP) was developed to assist private landowners in offsetting negative impacts of agricultural practices through government subsidies. To understand the contribution of currently enrolled CRP lands to broadscale landscape patterns, we used FRAGSTATS to assess patch- and class- scale landscape patterns in relation to grasslands across the state of Oklahoma at the statewide and ecoregion extents. At the statewide extent, CRP lands accounted for little change in grassland patterns, with only a 3.1% gain in grassland core area and 5.8% decrease in patchiness (number of patches). However, when assessed at the ecoregion extent, CRP lands contributed to significantly greater changes in grassland core area within the High Plains ecoregion (29.5% gain), while decreasing the patchiness in the High Plains and the Southwestern Tablelands (39.9% and 44.7%, respectively). Furthermore, our results suggest that the spatial arrangement of CRP lands within these ecoregions influences the overall change in patch configuration. For example, the proximity index of CRP lands is more influential in affecting grassland connectivity when compared to the overall coverage (%) of CRP lands within an ecoregion. Our results outline the importance of accounting for scale when assessing the impact of CRP lands on grassland landscape patterns.

DEVELOPMENT OF ECOSYSTEM SERVICE FRAMEWORK FOR CALIFORNIA RANGELANDS: A FOCUS ON SOIL HEALTH. Stephanie R. Larson-Praplan*[1], Roger Ingram[2], Holly George[3], Fadzayi Mashiri[4]; [1]UC Cooperative Extension, Santa Rosa, CA, [2]UC Cooperative Extension, Auburn, CA, [3]UC Cooperative Extension, Quincy, CA, [4]UC Cooperative Extension, Mariposa, CA

Land managers and conservationists are exploring different payments structures for the ecosystem services that flow from private and public rangelands. To better understand the overall management of ecosystem services and benefits received, a statewide project was created to focus on soil health; as it relates to a functioning ecosystem services. A soil health toolkit was created to educate rangelands owners, and agency personnel how soil health benefits the ecosystem services received from rangelands. The toolkit demonstrated assessment tools, from the very inexpensive (shovels) to the expensive (penetrometers), on soil structure, crusts, compaction, aggregate stability and biological activity. The toolkit incorporated soil health assessment tools with rangelands management practices, to promote improved soil health on rangelands. A created worksheet categorized soil health qualities into: physical, chemical, and biological and were combined with Natural Resource Conservation Service approved practices. Regional trainings were held in three different areas of California, covering a variety of ecological sites. These trainings increased awareness of practices that improve soil infiltration rates, water holding capacity, increased biodiversity, and forage production; promoting sustainable use of water resources. At each site, soil samples were taken with different soil analyses conducted. Results and interpretations were discussed; increased understanding on when and how to use soil sampling, and what management practices could be implemented for improved soil health. With emphases in California being placed on soil health, especially as it relates to climate change, drought, etc., trainings helped increased awareness of soil health, resulting in more resilient rangelands. Using appropriate tools for assessment and monitoring soil health, will increase rangeland resilience. The project will develop a framework that examines new ecosystem services payment structures. This will provide policy makers science based information for rangeland policy changes; and demonstrate to the public the importance rangelands in addressing climate change.

BRINGING DARK DATA INTO THE LIGHT: MINING US FOREST SERVICE RECORDS FOR TRENDS IN MANAGEMENT AND ECOLOGICAL CHANGE. Aaron M. Lien*, Natalya Robbins Sherman, Robert Merideth, George Ruyle, Laura López-Hoffman; University of Arizona, Tucson, AZ

Every year, the US Forest Service creates new management data in the form of Annual Operating Instructions and monitoring data on allotments. Periodically, environmental analyses are conducted to enable updating of Allotment Management Plans. Over time, these data have developed into a long-term record of how our public rangelands are managed and the ecological changes that have taken place. Unfortunately, these data are also difficult to access because they are most often located in paper files stored in ranger district offices scattered around the United States. These data are referred to as "dark data" – data that are collected, but lost or underutilized because they are forgotten or relatively inaccessible to managers and researchers who do not have access to the original records in paper file systems. In order to put these data to use, a massive effort is required to digitize them, code them, and organize them into a database that can be queried by interested researchers. In this presentation, we will review an ongoing effort in Arizona and New Mexico to create such a database for approximately 400 allotments in nearly 30

ranger districts across both states. The data collection, processing, and coding process will be reviewed, along with the process of translating key variables into a database that can be used to answer questions about the use of adaptive management in the US Forest Service's Southwest Region. This data collection effort is part of a larger interdisciplinary project to assess the impacts of adaptive management on range condition and socio-economics in the southwest.

PLANT DIVERSITY, DROUGHT AND GRAZING MANAGEMENT. Lee E. Hughes*; Retired BLM, Santa Clara City, UT

The grazing management efforts began on the Mt. Trumbull Allotment in the late 1960s. Management began in rotating cattle from low elevation pastures to high elevation pastures through the winter, spring, summer and fall..The grazing management and range improvements were formalized in a management plan in the late 1960s.

The focus will be on plant species frequency and composition and changes or maintenance of same .Early trend monitoring in small plots set in pastures in the late 1960s.. The trend of plant species was static through the 1970s. In the early 1980s, frequency and dry weight rank transects were placed across the allotment.The data from these transects are now 30 years old and shows high plant diversity-both forage and non-forage. Maintaining the plant diversity of 12-20 species through the last 30 years demonstrates proper use over the years.There are cool and warm season grasses, forbs, browse and shrubs.Forage and non-forage species are performing equally well.

The rancher has shown a keeness in moving the cattle at the right times with the use levels on the forage.This has occurred in wet and drought years. The emphasis of the discussion will be on the drought years from 1998 to the present and how species have held up under dry conditions under use levels experienced.

Poster Session I

1. WINTER BALE GRAZING EFFECTS ON SUBSEQUENT TAME FORAGE PRODUCTION IN THE NORTHERN GREAT PLAINS. Fara Brummer*[1], Kevin K. Sedivec[2], Mary Berg[3], Chris Augustin[4], Jackie Buckley[5], Sheldon Gerhardt[6], Penny Nester[7], Ashley Stegeman[8]; [1]Oregon State University, Lakeview, OR, [2]North Dakota State University, Fargo, ND, [3]North Dakota State University, Carrington, ND, [4]North Dakota State University, Minot, ND, [5]North Dakota State University, Mandan, ND, [6]North Dakota State University, Napoleon, ND, [7]North Dakota State University, Steele, ND, [8]North Dakota Department of Agriculture, Bismarck, ND

Bale grazing is the practice of allowing livestock winter access to hay bales in a hayfield or improved pasture to reduce feed delivery costs. Livestock growers in the northern Great Plains practicing this technique are also interested in improving soil health and forage production, while maintaining livestock performance. However, very little

published data is available addressing these impacts. An applied research project on four ranches in North Dakota is being conducted to examine winter hay bale grazing effects on subsequent forage production on improved pastures. Four bales per ranch were selected and vegetation clipped for biomass at four distance points along each cardinal direction from the bale center after cattle had grazed the bales. Hay residue was sampled at the same points to determine waste, and examine a possible relationship with forage regrowth. Four control points without bales were also clipped in the same fashion within the pasture. The most common perennial introduced grasses in the pastures were smooth brome (*Bromus inermis*), Kentucky bluegrass (*Poa pratensis*), and quackgrass (*Elymus repens*). Data after the first year of forage re-growth shows a positive trend between forage re-growth and bale grazing on three of the four ranches, and a negative trend on one ranch when compared with the controls. On average, forage increased 14.5 percent 1.5 m directly along the bales edge, 18.8 percent 1.5 m from bale, 38.5 percent 3 m from bale, and 71.5 percent 4.5 m from bale. On one ranch, excessive residue from wasted hay appears to have negatively affected the forage regrowth response. Another year of data collection on the same sites will allow us to examine forage response from nutrient release over time. Our completed project will include an annual cost analysis and outreach for technical information on bale grazing as a winter feeding practice.

2. THE CONTRIBUTION OF BISON DUNG AND URINE TO SOIL NITROGEN AND PHOSPHOROUS POOLS IN YELLOWSTONE NATIONAL PARK. Sydney Lundquist*[1], Anna Alexander[1], Bill Hamilton[1], Chris Geremia[2], Rick Wallen[2]; [1]Washington and Lee Univ, Lexington, VA, [2]National Park Service, Mammoth, WY

Yellowstone National Park is home to the largest population of free ranging genetically pure American bison (*Bison bison*). The current population estimate is 4,800 animals which utilize the parks grasslands throughout most of the year. In 2015, the National Park Service began an assessment of the effects of bison across the migratory range of both the Central and Northern Range herds and we present here a set of experiments conducted at a subset of 23 field sites across the altitudinal migratory gradient. The effects of bison a population this size on grassland ecosystems has not been determined and in this study we present the contributions of plant available nutrients returned to soil by bison dung and urine using natural and experimental applications of animal wastes. In all experiments we quantified KCl extractable pool sizes of soil ammonium, nitrate and phosphate using either soil cores or ion exchange membranes (IEM). At 5 sites in the northern range we applied simulated bovine urine and quantified N and P mineralization using ion exchange membranes for 40 days. At 2 sites we observed bison urination and collected soil cores for 3 weeks after deposition. At 12 sites we quantified the pool sizes of N and P in dung of varying ages and at 2 sites we homogenized fresh bison dung and reapplied dung pats to the soil surface and quantified pool sizes with IEMs for 10 days. IEMs unlike soil cores allow for the continuous trapping of mineralized N and P pools and our data shows that dung provides significant amounts of N and P while urine provides only N. The combined contribution of dung and urine to N and P soil pools represents a significant fertilizer effect ranging from 15-36 kg N/Ha and 3.5-7.1 kg P/Ha.

3. EFFECTS OF CONSERVATION PRACTICES ON ECOSYSTEM HEALTH IN THE RIO PUERCO WATERSHED. Jeremy W. Schallner*, Amy Ganguli, Nicole Pietrasiak, Kert Young; New Mexico State University, Las Cruces, NM

The Rio Puerco Watershed (RPW) is a highly dynamic and diverse ecological system that has a long history of anthropogenic alterations. Located at the southeast edge of the Colorado Plateau, the regional environmental conditions that drive the development of plant and animal communities in this watershed are highly variable in space and time. Flood and fire regimes have been altered by human activity, and prolonged periods of drought have intensified the transformation of the landscape. The RPW is currently recognized as the main source of suspended sediment in the Rio Grande after the confluence of the two river systems. Management within the RPW has focused on multiple uses, namely grazing and wildlife habitat, with brush encroachment and erosion as their primary ecological concerns. Prescribed grazing and brush management conservation practices are used on private and public lands throughout this watershed to improve their condition. Although, many changes in the plant and soil community have been noted visually and anecdotally, limited monitoring of these conservation practices have left a number of questions regarding treatment outcomes. The objectives of this project are to assess the effects of prescribed grazing and brush management conservation practices on plant and soil communities, wildlife habitat, hydrologic processes, and erosion in the RPW, and to provide a foundation for future range management decisions. Plant and soil community dynamics are being monitored using standard USDA methods, and runoff-monitoring plots including local weather observations are being established within the treatment areas. The methodological approach and preliminary data on existing plant community composition and structure will be presented as this project is in its initial phases. If conservation practices on rangelands within the RPW can decrease potential runoff and sediment load, the improvement of the ecological and hydrological stability would provide valuable water resources across the region.

4. LONG-TERM EVALUATION OF COOL-SEASON GRASSES SEEDED WITHIN THE SAGEBRUSH STEPPE IN CENTRAL- AND NORTHERN-UTAH. Clint Stonecipher*[1], Eric T. Thacker[2], Kevin Welch[1], Michael Ralphs[3]; [1]USDA-ARS, Logan, UT, [2]Utah State University, Logan, UT, [3]USDA-ARS, Ferron, UT

Revegetation on rangelands in the Intermountain west is conducted with long-term goals in mind. However, many trials only look at short-term data. The purpose of this study was to revisit plots that were originally seeded with cool-season grasses and forage kochia to suppress broom snakeweed and downy brome. Grasses were seeded in October 2003 and forage kochia in March 2004. The seeding treatments comprised of three introduced grasses, three native grasses, an introduced grass mix, a native grass mix, and forage kochia. The treatments were seeded into 3 by 15-m plots at Howell and Nephi, Utah within the sagebrush-steppe biome. Frequency and biomass measurements were

taken in 2015 to determine long-term persistence and forage production. At the Howell location, crested wheatgrass, pubescent wheatgrass, and western wheatgrass all persisted ($\geq 75\%$) and produced $1,520 \pm 168$, $2,160 \pm 168$, and $1,760 \pm 168$ kg/ha of forage, respectively. Russian wildrye and big squirreltail were still present at 35 and 20 %, respectively. Bluebunch wheatgrass and forage kochia did not persist ($< 2\%$). At the Nephi location, crested wheatgrass, pubescent wheatgrass, and western wheatgrass all persisted ($\geq 62\%$) and produced $3,760 \pm 552$, $3,200 \pm 552$, and $2,240 \pm 552$ kg/ha of forage, respectively. There was very little Russian wildrye and big squirreltail remaining ($\leq 13\%$) and no bluebunch wheatgrass remaining (1%). Forage kochia was still present at the Nephi site (41%). Our results suggest that crested wheatgrass, pubescent wheatgrass, and western wheatgrass can be used to rehabilitate disturbed landscapes due to their ability to establish and persist longer than 10 years.

5. A CLASSIC LONG-TERM STOCKING RATE STUDY REVISITED. Keith Harmoney*; Kansas State University, Hays, KS

After the Dust Bowl that gripped the Great Plains in the 1930's, researchers implemented studies in many states to determine recommended stocking rates that would sustain vegetative vigor, cover, and production and provide a sustainable income stream from grazing animals. One such study occurred on the western rangelands of Kansas. In 1946, John Launchbaugh and Frank Kessler, both stationed in Hays, KS, initiated a long-term stocking rate study to compare stocker animal production and vegetative production at light, moderate, and heavy stocking rates through the growing season. This 20 year study, reported from 1946-1965, showed that individual animal gains declined as stocking rate increased beyond a moderate level, and that pasture yield was inversely related to stocking rate. With increasing stocking rate, composition shifted toward low yielding buffalograss and away from greater yielding western wheatgrass and blue grama. Previously unreported, the heavy and light stocking rate treatments were reversed from 1967-1971. Within five years of the reversal, the dry matter production in pastures also reversed. Following the reversal, buffalograss composition rapidly declined and western wheatgrass rapidly increased in the heavy to light pasture. The light stocked pasture also changed composition after the reversal to a heavy stocked pasture, but the change was not as drastic. Composition changes occurred at a slower rate transitioning from a light to heavy stocking rate than when transitioning from a heavy to light stocking rate. At this site, desirable western wheatgrass appears at a faster rate from reducing stocking rate than it disappears from increasing stocking rate. In shortgrass rangelands over utilized for over 20 years from heavy stocking rates, great improvements in rangeland health are possible within five years by simply lowering the stocking rate.

6. IMPACTS OF ECOLOGICAL SITES AND HERBIVORY ON SOIL SEED BANKS AND VEGETATIVE PROPAGULES. Lan Xu*[1], Patricia S. Johnson[1], John R. Hendrickson[2], Kevin K. Sedivec[3], Jameson R. Brennan[4], Surendra Bam[1]; [1]South Dakota

State University, Brookings, SD, [2]USDA-ARS, Mandan, ND, [3]North Dakota State University, Fargo, ND, [4]South Dakota State University, Rapid City, SD

The capacity of vegetation to regenerate after disturbance is depend on the presence of seed banks and vegetative propagules, which are affected by various abiotic and biotic factors, such as ecological sites and herbivory. They also reflect the land use history. This study aimed to determine the characteristics of seed banks and vegetative propagules under different ecological sites (Loamy *vs*. Clayey), grazing disturbance (presence *vs*. absence), and types of grazing (livestock *vs*. prairie dogs), intensity of disturbance on the composition, abundance, and viability of seed and vegetative propagules reserves for consecutive three years. Within each ecological site, locations were selected in areas with no grazing, grazing by prairie dog only, grazing by cattle only and grazing by both herbivores. At each location, two prairie dog burrows (on-town) or sampling points (off-town) at least 2-m apart were randomly selected. Two soil cores were taken at 0.5-m, 1-m, and 2-m from the center of each burrow or sampling point. One core was used to evaluate the seed bank while the other was examined for vegetative propagule reserves. The soil cores and seed flats were maintained in a greenhouse with ambient photoperiod during the 2014 to 2016 growing seasons. Samples were misted daily and emergence was recorded weekly. Plants were identified as they emerged, counted, and then removed. Species richness, abundance, viability, and similarity of seed bank and vegetative propagules will be determined. The information generated from this study will increase our knowledge of understanding vegetation trajectory recovery following disturbance and potential role of soil seed bank and bud bank in providing resilience of grassland ecosystems to the changing environmental conditions. In addition, it provides insights for developing strategies for sustainably managing co-existence of prairie dogs and livestock.

7. HOW THE RANGELAND COMMUNITY STUDIES RANGELAND COMMUNITIES--SYSTEMATIC REVIEW OF COMMUNITY ECOLOGY IN SRM JOURNALS. Devan A. McGranahan*[1], James C. Church[2]; [1]North Dakota State University, Fargo, ND, [2]La Salle University, Philadelphia, PA

Rangeland ecologists have long worked at a community level and increased attention to the role of biodiversity on ecosystem function has placed greater importance on how we measure and analyze diversity. Conventional measurements such as species richness and diversity indices are simple to calculate and make intuitive sense, but they often fail to account for useful information in species composition data. Multivariate procedures take species identities into account and can describe dissimilarities along environmental gradients, and their use throughout ecology is increasing. We systematically review 153 papers published between 1967 and 2016 that report species composition and/or diversity data in the Society for Range Management research journals (Journal of Range Management and Rangeland Ecology and Management) and delineate four categories of community analysis along a gradient of Very Weak to Very Strong, depending on the level of information on species identity and environmental/management gradients incorporated into the analysis. We identify a trend in the frequency of multivariate

techniques; although their use has historically been limited by computational power and access to proprietary software, the Internet has connected an ecology-minded community that has developed numerous analytical options built around free, open-source software. To illustrate the ease-of-use and explanatory power of multivariate analysis and demonstrate potential pitfalls of using diversity indices to describe community composition along environmental gradients, we calculate and compare diversity indices and ordinations using an example dataset in the open-source R statistical environment.

8. LINKING ANIMAL, WILDLIFE AND CRITICAL SOCIAL RESEARCH FOR COLLABORATIVE ADAPTIVE RANGELAND MANAGEMENT. Hailey Wilmer*[1], Amber Carver[2], Tamarah R. Plechaty[3], Michelle Olsgard Stewart[4], Kristin Davis[4], Justin D. Derner[5]; [1]USDA Northern Plains Climate Hub, Fort Collins, CO, [2]University of Colorado-Denver, Denver, CO, [3]University of Wyoming, Laramie, WY, [4]Colorado State University, Fort Collins, CO, [5]USDA-ARS, Cheyenne, WY

Rangelands of the western Great Plains of North America are complex social-ecological systems where management objectives for collaborative learning, livestock production and grassland bird habitat conservation converge. This complexity requires collaboration among diverse disciplines to address social and ecological issues. This study synthesizes animal, wildlife and critical social science research conducted by graduate students and early career researchers on the Collaborative Adaptive Rangeland Management (CARM) experiment conducted at the USDA-ARS Central Plains Experimental Range, a Long-Term Agro-ecosystem Research (LTAR) network location. CARM is a 10-year collaborative adaptive management (CAM) project (initiated in 2012) where 11 stakeholders representing ranchers, state/federal land managers and conservation NGOs have worked with researchers in decision-making informed by extensive and spatiotemporally explicit ecological monitoring. Stakeholders manage a herd of yearling steers using pulse grazing on 2600 ha (10 paired 130 ha pastures) of shortgrass steppe for objectives related to 1) livestock production, 2) grassland bird habitat and 3) vegetation. Here, we evaluate the efficacy of CARM, compared to traditional rangeland management (TRM, season-long grazing, mid-May to October at a moderate stocking rate) on a) influencing community stability, abundance and reproductive success of grassland birds; b) affecting diet quality, nutritional plane and energetic expenditure of yearlings during two grazing seasons; and c) promoting meaningful collaboration and inclusion of diverse knowledges. Our results indicate that 1) vegetation drives abundance and nest placement for grassland birds, but nest survival is more strongly influenced by weather than management 2) yearlings grazing in the TRM pastures had a consistently higher plane of nutrition through measured diet quality and 3) existing stakeholder systems of knowledge enhance adaptive decision-making and meaningful collaboration requires inclusion of stakeholders throughout the entire project design. These results suggest that iterative, stakeholder-focused CAM processes are enhanced by multidisciplinary research approaches that address multiple social-ecological management objectives on rangelands.

9. SEEDING FUNCTIONAL REDUNDANCY FOR MULTIPLE ECOSYSTEM SERVICE GOALS.

Danny J. Eastburn*[1], Leslie Roche[1], Morgan P. Doran[2], Elise S. Gornish[1]; [1]University of California, Davis, Davis, CA, [2]University of California Cooperative Extension, Woodland, CA

California annual rangelands are some of the most highly invaded systems in the world. The widespread invasion of these systems, by a multitude of invasive plant species, has led to significant losses in multiple economic and ecological benefits. In order to assess if rangland seeding can enhance multiple ecosystem services in heavily invaded rangeland plant communities, we conducted an 11 year study to investigate long-term management outcomes of seeding of annuals, natives, and non-native perennial forage species, including (1) occurrence of three dominant invasive plants—Medusahead (*Taeniatherum caput-medusae*), jointed goatgrass (*Aegilops cylindrica*), and yellow starthistle (*Centaurea solstitialis*); and (2) response of species diversity and native richness. We used a randomized complete block design with four blocks and five seeding treatments per block. We found differences in the responses of multiple ecosystem service metrics across seeding treatments and controls. For example, exotic perennial and mixed exotic-native perennial seeding treatments provided more resistance to invasion of *C. solstitialis* than the annual, native perennial, or control groups. All seeding treatments were resistant to *T. caput-medusae* while, contrastingly, all treatments provided little resistance to *A. cylindrica*. We observed greater diversity in native and mixed seeding treatments relative to controls, and greater establishment of native species over the course of the study. The findings of this study will be beneficial to support land manager decision making and goal setting.

10. EFFECTS OF *PROSOPIS GLANDULOSA* MORTALITY ON HERBACEOUS COMPOSITION AND PRODUCTIVITY AND SOIL NITROGEN POOLS.

Kim Peters*[1], Tim Steffens[1], R. James Ansley[2], Kathryn Radicke[3], Eric Bailey[3], William Pinchak[4], Rick Haney[5]; [1]West Texas A&M, Canyon, TX, [2]Oklahoma State University, Stillwater, OK, [3]West Texas A&M University, Canyon, TX, [4]Texas A&M AgriLife Research, Vernon, TX, [5]USDA-ARS, Temple, TX

Live honey mesquite (*Prosopis glandulosa*) trees create "islands of fertility" beneath their canopies. Our objective was to determine the impact of herbicide induced mesquite mortality on soil nutrients and herbaceous communities beneath the canopies and in interspaces between trees. The study was a randomized complete block design, blocked by site type (two blocks: four upland sites, two lowland sites). Each site had one replicate of an untreated control, one aerial broadcast herbicide treatment in 2013 and one in 2014. In each replicate, three 1x2 meter grazing exclosures were placed under the canopies and three in the interspaces. During peak cool- and warm-season herbaceous standing crop, herbage was clipped by functional group to ground level in a 0.125 m2 frame in the exclosure, dried in a forced-air oven at 60°C for 48 h, and weighed. In addition, soil cores

are taken at 0-15.25 cm and 15.26-30.5 cm and composited under the canopies of trees and in the interspaces. Light measurements were taken with a photometer under the canopies of one tree in each rep. In 2015, production of cool season perennial grasses was at least 40% higher and total perennial grass production was at least 35% higher in treated areas versus control areas; however, warm season grass production was not significantly different between treatments and controls. During peak cool season standing crop in 2016, production of annual grasses and annual forbs were twice as high in the 2013 treatment than in the control. Inorganic nitrogen levels were significantly higher during this sampling time. This, along with rainfall timing and amounts, likely contributed to the flush of annuals, which in turn suppressed the growth of perennials in the 2013 treatment. While mesquite mortality results in increased herbaceous production, the proportional difference in plant functional group productivity may vary.

11. TESTING RELATIONSHIPS BETWEEN PLANT SPECIES RICHNESS AND MULTIPLE ECOSYSTEM FUNCTIONS BASED ON EXPERIMENTAL EXTINCTION SCENARIOS. Yu Yoshihara*[1], Takehiro Sasaki[2]; [1]Mie University, tsu, Japan, [2]Yokohama national university, yokohama, Japan

Ecosystem functions are threatened by ongoing global biodiversity loss. Both Multifunctionality and realistic nonrandom extinction scenario are noteworthy approaches for valuing ecosystem function along with the biodiversity loss from the view of ecosystem management. We thus investigated four ecosystem functions simultaneously following potential species extinction scenarios seen in real Mongolian grassland. ANPP, forage nutrient values, litter decomposition and soil respiration were measured 1 and/or 2 years after the plant removal experiment. DNA sample of microorganisms extracted from the soil was subjected to the next-generation sequencing. Among ecosystem functions, ANPP and litter decomposition rate were decreased and forage quality was increased under random, rare species and dominants species first removal scenario, respectively. Diversity and species composition of soil microorganism was not patterned by plant species richness and removal scenario. Only the relationship between genus-level diversity of bacteria and ANPP had significant correlation among the microbial diversity and ecosystem functions. Because complimentarily effect worked against realistic species decline in Mongolian natural grassland, plant species loss not always lead to reduction of multiple ecosystem functions. However, each function responded differently to the species loss order, realistic nonrandom extinction scenario and multifunctionality approaches should be involved into the research between biodiversity and ecosystem functions to prepare for the ongoing biodiversity loss by various disturbances.

12. WEIGHT GAIN AND BEHAVIOR OF RARAMURI CRIOLLO VERSUS CROSSBRED STEERS DEVELOPED ON CHIHUAHUAN DESERT RANGELAND. Matthew M. McIntosh*[1], Andres F. Cibils[1], Rick E. Estell[2], Sergio A. Soto-Navarro[1],

Alfredo L. Gonzalez[2], Shelemia Nyamurekunge[1], Sheri Spiegal[2]; [1]New Mexico State University, Las Cruces, NM, [2]USDA ARS, Las Cruces, NM

Ranchers that raise Raramuri Criollo (RC) cattle must overcome the challenge of lack of markets for weaned calves. Growing and finishing RC or RC-crossbred steers on rangeland pastures is increasingly common; however, no data exist on their weight gains or grazing behavior. We tracked the weight and behavior of four groups of steers in the Chihuahuan Desert to understand the viability of this production approach. Nineteen 8-month steers (eleven RC, RC-8, and eight Brangus×Criollo, BRCR-8) and nineteen 17-month steers (ten RC, RC-17; nine Waguli×Criollo, WACR-17) were weighed every 60 days between 12/2015 and 10/2016 to determine individual body weight (WT), average daily gain (ADG), and body condition score (BCS). In addition, we used Lotek 3300 GPS collars to monitor location (at 5-minute intervals) of five RC-17 and five WACR-17 individuals in 12/2015. Influence of breed on WT, ADG, BCS and behavior was analyzed using repeated measures mixed ANOVA treating steers as experimental units. Separate comparisons were conducted within each age group. Crossbreds were heavier than their RC counterparts at the beginning of the study and WT differences in both groups persisted throughout (P<0.01). ADG of RC-17 and WACR-17 were not detectably different, however BRCR-8 steers showed higher ADG than their RC-8 counterparts (P < 0.014). BCS of crossbreds was significantly higher than that of RC steers in both age groups throughout (P< 0.01). Overall, RC-8, BRCR-8, RC-17, and WACR-17 gained on average 158, 203, 166, and 156 lb head-1 11 months-1, respectively. Daily distance traveled by WACR-17 and RC-17 did not differ, however WACR-17 walked farther during nighttime hours (P <0.01) and followed less sinuous movement trajectories (P<0.01) than their RC-17 counterparts. Although WT gains at a younger age were improved by crossbreeding RC with Brangus, further research is needed to determine performance of older BRCR and younger WACR crossbreeds.

13. VULNERABILITY OF GRAZING AND CONFINED LIVESTOCK IN THE NORTHERN GREAT PLAINS TO PROJECTED MID- AND LATE- 21ST CENTURY CLIMATE. Justin D. Derner*[1], David D. Briske[2], Matt C. Reeves[3], Tami Brown-Brandl[4], Miranda A. Meehan[5], Dana M. Blumenthal[6], William Travis[7], David J. Augustine[6], Hailey Wilmer[8], Derek Scasta[9], John R. Hendrickson[10], Jerry Volesky[11], Laura Edwards[12], Dannele Peck[6]; [1]USDA-ARS, Cheyenne, WY, [2]Texas A&M, College Station, TX, [3]USDA Forest Service, Florence, MT, [4]USDA-ARS, Clay Center, NE, [5]North Dakota State University, Fargo, ND, [6]USDA-ARS, Fort Collins, CO, [7]Western Water Association, University of Colorado Boulder, Boulder, CO, [8]USDA Climate Hub, Fort Collins, CO, [9]University of Wyoming, Laramie, WY, [10]USDA-ARS, Mandan, ND, [11]University of Nebraska, North Platte, NE, [12]South Dakota State University, Brookings, SD

The Northern Great Plains (NGP) region – Montana, Wyoming, Colorado, North Dakota, South Dakota and Nebraska – is a largely rural area that provides important agricultural and ecological services, including biological diversity. The NGP is projected to experience rising atmospheric CO_2, warming and longer growing seasons, along with

enhanced climatic variability and more extreme events (e.g., greater occurrence of large precipitation events). These climatic changes, independently and in combination, may affect livestock production both directly via physiological impacts on animals and indirectly via modifications to forage, invasion of undesirable plants and the abundance of and temporal exposure to ectoparasites. This raises concerns regarding the vulnerability of livestock grazing and confined livestock operations to projected changes in mid-(2050) and late-(2085) 21st century climate. Our objectives were to: 1) describe the exposure of the NGP to temperature and precipitation trends, inter-annual variability, and extreme events, 2) evaluate the sensitivity of beef cattle production to the direct and indirect effects imposed by these climatic projections, and 3) provide a typology of adaptive capacity to optimize the beneficial and minimize the adverse consequences of projected changes. The vulnerability of NGP to projected climatic changes will be determined not only by modification of ecological responses, but also by the adaptive capacity of individual managers. Adaptive capacity in the NGP will differ from other regions because projections suggest opportunities for increased livestock production. Adaptations in both grazing and confined livestock systems will require enhanced decision-making that emphasizes integration of biophysical, social and economic components. Many adaptations for these systems have already been implemented, at least in a limited fashion in this region, providing opportunities for assessment and further development and adoption. Science-management partnerships aimed at adaptive capacity building, such as collaborative adaptive management, support context-specific decision-making for operations involving consideration of multiple production and conservation objectives.

14. TILLER DYNAMICS OF TWO PERENNIAL GRASSES IN RESPONSE TO CLIPPING AND SOIL MOISTURE REGIMES. Surendra Bam*[1], Lan Xu[1], Jack L. Butler[2], Jacqueline Ott[2]; [1]South Dakota State University, Brookings, SD, [2]US Forest Service, Rapid City, SD

Tiller recruitment of perennial grasses in mixed-grass prairie primarily occurs from belowground bud banks. Environmental conditions, such as grazing and soil moisture regimes can affect the tiller recruitment and their dynamics of both native and invasive perennial grasses. Increased climate variability is likely to interact with other disturbances, such as grazing which may profoundly impact grassland community structure and function by affecting competitive dynamics between native and invasive species, and potentially undermining the effectiveness of restoration activities. The objective of this study was to compare tiller dynamics of native western wheatgrass (*Pascopyrum smithii*) and invasive smooth bromegrass (*Bromus inermis*) to main and interacting effects of clipping and soil moisture regimes under controlled temperature condition. A greenhouse experiment consisted of the combinations of three moisture regimes (VWC; 25%, 14% and 8%) and two clipping (clipping and no-clipping) with 240 replications for each species. Single-leaf seedling of each species transplanted in each individual potting-soil filled pot (16.5 cm diameter). Clipping treatments were applied at 2-leaf stage. New tiller was marked and recorded daily. Tiller recruitment data were analyzed. We found significant effect of soil moisture regime, species, and clipping

(P<0.05) on total tiller number, relative tiller number, and tiller natality (tillers tiller-1 day-1) but no interactions. The weekly tiller recruitment was significantly higher for smooth bromegrass than western wheatgrass for both clipped or no-clipped treatments. Weekly percentage change in tiller number were significant for lowest soil moisture level. Further, weekly tiller recruitment of smooth bromegrass under low soil moisture level significantly lower compared to western wheatgrass in 4th and 12th week because of some difference in water stress tolerance. The results provide insight into the factors influencing vegetation dynamics of two important Great Plains grass species and will help for development of adaptive grazing management plans under predicted scenarios of climate change.

15. ORGANIZED MARKETING OF NICHE LIVESTOCK PRODUCTS MAY IMPROVE PRODUCTION VIABILITY. Fadzayi E. Mashiri*[1], Stephanie R. Larson-Praplan[2]; [1]UC Cooperative Extension, Mariposa, CA, [2]UC Cooperative Extension, Santa Rosa, CA

Beef cattle and products are the fourth leading agricultural industry in California, according to the latest beef industry statistics. However, many livestock producers struggle to remain viable in conventional marketing operations due to a combination of high production costs, low productivity and low sale prices. Marketing niche livestock products, for example grass fed beef, free ranging poultry and pork, directly to local markets, is emerging as a viable alternative. Niche livestock products appeal to a growing market interested in paying premium prices for locally-produced food that has healthier qualities. Locally produced niche livestock products are limited in Central Valley Counties of California and some producers are seeing an opportunity to capture this market and improve economic viability, especially given their access to places like Yosemite. In the past, some producers set aside a few herd for niche marketing, but had problems securing reliable markets because most prefer producers that could supply products year round. To address this problem, we are facilitating ranchers to organize into a group so they can develop strategies to coordinate their production and sales to ultimately become competitive suppliers to larger markets. Informational and exploratory meetings were held with interested producers, discussed laws which regulate grass fed beef production, along with marketing standards for niche products. We continue exploring the ideal structure for the group (cooperative vs. individual brands) and identifying short- to long-term goals. Increasing visibility of grass fed beef, raised on California rangelands, will benefit and hopefully increase the use of rangelands for local beef production. With this poster we will share the challenges and lessons learned in this process to this point.

16. HOW TO ESTIMATE UTILIZATION OF GRASSES: OCULAR ESTIMATION OR HEIGHT-WEIGHT METHOD? Janessa C. Julson*[1], Karen Launchbaugh[1], Courtney Conway[2]; [1]University of Idaho, Moscow, ID, [2]U.S. Geological Survey, Moscow, ID

Utilization measurements of grass are often used to guide rangeland management decisions. However, estimating utilization can be difficult to an untrained eye. Two common techniques to estimate utilization are ocular estimation and using height-weight relationships to deduce utilization based on reduced height. We compared these two ways to estimate utilization on individual bunchgrass species in sagebrush-steppe ecosystems at four study sites in Southern Idaho. Study sites consisted of Wyoming big sagebrush (*Artemisia tridentata* subsp. *wyomingensis*) and low sagebrush (*Artemisia arbuscula*) overstory with an understory of perennial bunchgrasses. Observers measured maximum droop height and estimated utilization in 5% increments of individual grasses. We also collected ten ungrazed samples of eight perennial bunchgrass species: Indian ricegrass (*Achnatherum hymenoides*), Thurber's needlegrass (*Achnatherum thurberianum*), crested wheatgrass (*Agropyron cristatum*), Bottlebrush squirreltail (*Elymus elymoides*), Idaho fescue (*Festuca idahoensis*), needle and thread (*Hesperostipa comata*), Sandberg bluegrass (*Poa secunda*), and bluebunch wheatgrass (*Pseudoroegneria spicata*). In the lab, we recorded the maximum height from ground level, clipped biomass at 10% increments of the max height, dried, and weighed each sample. We created height-weight curves for each of the eight grass species. We then used these curves to quantify utilization of grazed grasses in the field and compared ocular estimates to the quantified measures. We also compared these curves to height-weight utilization gauges used as a standard method by agencies.

17. USE OF SOLID MATRIX PRIMING AND EXTRUSION TECHNOLOGY TO IMPROVE SEED GERMINATION TIMING. Rhett M. Anderson*, Matthew Madsen, William C. Richardson, Karma Phillips, Thomas Bates, Dallin Whitaker, Gabriel Poulson; Brigham Young University, Provo, UT

In the western United States, overgrazing and fires have damaged rangelands and led to invasive grass species moving into formerly native sagebrush-steppe systems. Reseeding is a common practice that attempts to restore native plant communities and ecological function back into the ecosystem. However, many invasive annual weed species such as *Bromus tectorum* have a faster germination time than native seeded species, which appears to give them an advantage in dealing with harsh temperature and soil moisture environments. A possible solution to this problem is to prime the native seeds so they have similar germination characteristics as the invasive weeds. We primed seeds of *Pseudoroegneria spicata*, *Elymus elymoides* and *Linum lewisii* in a matrix of compost, clay, and chemical bio stimulants. Seeds were primed at -1.5 Mpa over a range of 1-7 days. After priming the seed and matrix material was extruded into pellets. Untreated seed and seed primed under the different priming durations were germinated in petri-dish at constant temperatures of 5, 10, 15, 20 and 25oC. Wet thermal accumulation models were developed from seed germination data and applied to historical field temperature and moisture data from various sites in the Great Basin to estimate germination timing

and predict seed performance in the field. Preliminary analysis appears to show that primed extruded pellets sown in the fall will provide seedlings with additional time to produce biomass to enhance their survival through the winter period. If seeded in the spring, early germination from primed pellets may allow seedlings to develop sufficiently so they can survive through the upcoming summer drought. Future field work is needed to verify the results of this research.

18. NOVEL APPROACH FOR IMPROVING RANGELAND SEEDING SUCCESS WITH IMAZAPIC HERBICIDE, CULTIVATOR SWEEPS, AND A RANGELAND DRILL. Jesse R. Morris*[1], Matthew Madsen[2], Jace Taylor[2], Steven Petersen[2], Clair R. Lawrence[3], Val J. Anderson[2]; [1]Brigham Young University, Orem, UT, [2]Brigham Young University, Provo, UT, [3]Hill AFB and Utah Test and Training Range, Hill AFB, UT

Revegetation efforts in degraded rangeland systems often fail due to low precipitation and competition from invasive weeds. Use of soil active herbicides, such as imazapic, provides land managers with a tool for controlling invasive weeds. However, when seeding is performed concurrently with herbicide application practitioners struggle with applying herbicide at rates sufficient to achieve weed control without damaging seeded species. We evaluated a novel approach for applying imazapic herbicide and seeding within a one-pass system. Using a John Deer 6330 tractor and P&F Services rangeland drill we mounted a boom sprayer at the front of the tractor, and then at the back of the tractor a tool bar with cultivator sweeps that were adjusted so they were directly in-line with the rangeland drills planter disks. During operation, the cultivator sweeps created a furrow that removed imazapic treated soil away from the drill row. To evaluate each component of the one-pass system we applied the following treatments within a randomized complete block design: 1) drill only (control), 2) cultivator sweeps + drill, 3) imazapic + drill, and 4) imazapic + cultivator sweeps + drill. Relative to the control, imazapic + cultivator sweeps reduced *B. tectorum* cover by 76%. Both cultivator sweep treatments increased volumetric water content in the bottom of the drill row. Imazapic + cultivator sweeps was the only treatment to significantly improve plant density of seeded species, which produced 11.8 plants m-2 in comparison to the control that had 4.5 plants m-2. These results indicate that a one-pass system with imazapic and cultivator sweeps may be an effective method for decreasing weed cover and improving revegetation success.

19. NOVEL TECHNIQUES FOR IMPROVING SAGEBRUSH SEED DELIVERY. Thomas Bates*, Matthew Madsen, Ryan Call, Rhett M. Anderson, Benjamin Hoose; Brigham Young University, Provo, UT

The declining sagebrush (*Artemisia* spp.) biome has long been a subject of much interest among ecologists and other rangeland professionals. Many efforts have been made to restore Wyoming big sagebrush (*Artemisia tridentata* Nutt. ssp. *wyomingensis*) on degraded rangelands, but due to its poor germinability and the difficulty of seed delivery,

few attempts have been very successful or cost effective. The difficulty in seeding sagebrush is a direct function of the seed composition. Sagebrush seed lots are typically low in purity and can contain anywhere from 70-90% non-seed parts (i.e. achenes, seed bracts, leaves and fine stems). In order to combat the problems of small seed size, seed box bridging, aerial drift, and poor germination we have developed a new seed coating technique that increases relative "seed size" and density, improves seed flowability and enhances seed germination. We will present preliminary research associated with the development of this patent pending technology and discuss its potential benefits for improving rangeland seeding success.

20. SUSTAINABLE GRAZING LANDS IN COLORADO: MEASURING OUTCOMES FOR CONSERVATION, CATTLE, AND CARBON. Terri Schulz*[1], William Burnidge[2], Teresa Chapman[2], Chris Pague[2], John Sanderson[2]; [1]The Nature Conservancy of Colorado, Fort Collins, CO, [2]The Nature Conservancy of Colorado, Boulder, CO

The Nature Conservancy in Colorado is advancing a Sustainable Grazing Lands program to improve conservation, economic, and social outcomes on grazing lands. For a Sustainable Grazing Lands program to get to scale, it must be informed by solid science merged with robust planning and implementation. This poster presents the early results of a multi- year effort to develop a framework for defining and assessing sustainability. To test this framework, we are collecting and assessing data from pilot ranches where we are implementing sustainable grazing planning and implementation.   We hypothesize that "if we systematically plan for better ecological, economic, and social outcomes—and adaptively manage to that plan—then domestic livestock grazing will lead to greater biodiversity, increased plant productivity, higher levels of carbon storage, and improved economic viability for ranching families." Across four pilot ranches in eastern Colorado we worked with ranchers to co-develop management plans. We then sampled vegetation and soil organic carbon (SOC), and used MODIS and LANDSAT remote sensing data to assess vegetation productivity and, where possible, compare it to control ranches. Also, Greater Prairie Chicken surveys were conducted by Colorado Parks and Wildlife on one ranch to assess effects on an important conservation target. Of the four ranches, two ranches are close to reference condition for vegetation composition, and one is serving an important role in conserving Greater Prairie Chicken. Two other ranches were degraded when the study began because of past management. For one degraded ranch dominated by annual grasses following drought, preliminary results indicate soil carbon levels that are only 50% of similar reference soils. In the future. we intend to continue assessments of vegetation condition, productivity, wildlife responses, and SOC, as well as begin assessments on social and economic impacts.

21. INTEGRATED LENTIC RIPARIAN GRAZING MANAGEMENT. Sherman R. Swanson*; University of Nevada, Reno, Reno, NV

Managing lentic riparian areas for functionality is a legal, policy, sustainability, wildlife & common sense requirement. Yet lentic riparian work has been neglected without an effective integrated riparian management process. **1**- Assess lentic riparian areas for proper functioning condition (PFC). With areas in PFC, stabilizing plants capture sediment, dissipate or resist erosive energies, and accumulate organic matter to sustain the sponge for water and nutrients to nourish stabilizing plants. **2** - Identify resource values, or types of habitat. Livestock production often depends on riparian vegetation to extend periods and amounts of nutritious green forage. Endangered, threatened, or sensitive species at springs depend on specific aquatic or riparian habitats. **3** - Prioritize riparian areas for management, restoration, or monitoring using steps 1 and 2. **4** - Identify issues, and establish goals, and objectives for key areas. Riparian vegetation usually drives recovery and objectives. It slows runoff to trap sediment and expand zones of wetness, dissipates or resists erosive energies to stabilize soil, and re-builds the organic sponge for water that nourishes stabilizing, forage, and habitat plants. **5** - Design and implement management and restoration actions. Many strategies that apply grazing management principles are effective for riparian recovery. Principles are: A. Strengthen important forage plants with only short periods of use OR moderate grazing intensity during the growing season; B. Provide sufficient growing season recovery before next use; and C. Graze at a different time from one year to the next. **6** - Monitor and analyze the effectiveness of actions by focusing on objectives addressing threats to riparian functions and targeted resource values. **7** - Implement adaptive actions. Riparian management must be adjusted by using monitoring information. Strategies developed for grazing management of streamside riparian areas can be applied with monitoring focused on the driving variables for lentic riparian recovery.

22. AMOUNT AND FREQUENCY OF WATER SUPPLY, EFFECTS IN DEVELOPMENT OF INITIAL STAGES OF RANGELAND GRASSES. Aldo Sales*[1], Carlos Villalobos[2], LEOBARDO RICHARTE[3]; [1]Texas Tech University, Lubbock, TX, [2]Texas tech university, Lubbock, TX, [3]Texas tech University, LUBBOCK, TX

Moisture is the major factor determining the success of the seedling establishment in arid lands. Thus, our goal were to investigate the effect of amount and frequency of watering events on two successional (late and mid-seral) grasses species of the western U.S. The study was conducted in greenhouse condition simulating the warm season temperature and humidity (May-August) in the South Plains of Texas. We simulated three summer monthly precipitation regimes (May–August) based on Long-term Precipitation Average (LPA) of Lubbock-Texas. The precipitation regimes treatments were: 1o) LPA, 2o) Dry regime (75% below of the LPA), and 3o) Wet regime (Average of ten-years with highest precipitation in the LPA). Also, we used the monthly precipitation to simulate three watering patterns: 1) monthly precipitation distributed in six events 2) monthly precipitation distributed in four events, and 3) monthly precipitation distributed in two events. Blue grama (Bouteloua gracilis) and Kleingrass (Panicum coloratum) were grown in 90 pots each contend 19 kg of soil. The germination and survival rate were measured weekly. 120 days after planting the plants were washed from the pots with cold water and measured the following variables: Biomass total (g of dry-matter), shoot and root length

(mm). The data was subjected to analysis of variance and means were compared by Tukey test (P<0.05). The plants showed high mortality in dry years when the monthly precipitation was divided in six times There was correlation between water available and root biomass in Blue grama, but there was not in Kleingrass. We believe strongly that this result is related with genetic factors associated with adaptations to water-limited conditions. Our results suggest the existence of an optimum range between frequency and amount of water inputted to the system of each plant species. This optimum range allows the seedling survival, establishment success, and initial development.

23. MULCH AND POLYACRYLAMIDE FOR INCREASING SOIL MOISTURE AND SEEDING SUCCESS. Shannon V. Nelson*, Wyatt Petersen, Jeffrey Svedin, Matthew Madsen, Val J. Anderson, Neil C. Hansen, Bryan G. Hopkins; Brigham Young University, Provo, UT

The US Air Force trains with live munitions on a desert range west of Salt Lake City, Utah. They are committed to ecological restoration on lands damaged by resultant fire. However, revegetation is challenging due to low average annual rainfall of 25 cm. The US Air Force trains with live munitions on a desert range west of Salt Lake City, Utah. They are committed to ecological restoration on lands damaged by resultant fire. However, revegetation is challenging due to low average annual rainfall of 25 cm. Applications of surface coir mulch or subsurface polyacrylamide (PAM) were evaluated to determine the effects on establishment of crested wheatgrass, yellow sweet clover, Wyoming big sagebrush, forage kochia, Lewis flax, and bottlebrush squirreltail under glasshouse conditions. Seeds were planted in a loam soil and then watered once to saturation. For the mulch trial, seeds were planted in 79 cm2 pots. All species had greater emergence with 310 g mulch m2—ranging from 56% to >500% increase and with wheatgrass, Wyoming big sagebrush, Lewis flax, and bottlebrush squirreltail seedlings living 2-3 days longer. For the PAM trial, seeds were planted at the bottom of a furrow in 0.13 m2 boxes with 0.04 m between top of the ridge and bottom of the furrow and 0, 20, or 40 g PAM band-1 applied at 0.08 m below soil surface in the furrow, with 0.03 m of soil below the band. Each species was planted separately in a row perpendicular to the furrow. Beginning at 8 days after planting, volumetric soil moisture in the furrow was 200 and 500% greater than the control at 20 and 40 g PAM, respectively, on day 21. Lewis flax, yellow sweet clover, crested wheatgrass, and forage kochia lived 10, 12, 13, and 23 days longer than the control for the 40 g treatment. Both of these treatments have promise for success in limited acreage plantings, although further studies are needed to evaluate mulch/PAM combinations with seeding rate reductions to avoid excessive competition.

24. INCREASING CARBON AND NITROGEN IN TAILINGS 17 YEARS AFTER A ONE-TIME BIOSOLIDS APPLICATION. Michelle E. Phillips*[1], Wendy C. Gardner[2],

Tom Pypker[1]; [1]Thompson Rivers University, Kamloops, BC, [2]Thompson Rivers University, kamloops, BC

In 2015, a field study was conducted on two texturally different copper mine tailings in British Columbia, Canada. The objective of the study is to determine the long term response of carbon and nitrogen concentrations and identify if there is a long term benefit of a one-time biosolids application during mine tailings reclamation. In August 1998, anaerobically digested biosolids were applied in a randomized complete block experimental design to a sand and a silt loam tailings pond at rates of 0 (control), 50, 100, 150, 200 and 250 Mg ha-1. In July 1999 all experimental plots were seeded with an agronomic seed mix. Soil samples were taken from a depth of 0-15 cm, September 1998, 1999 and 2000 (1, 13, and 25 months after biosolids application) and 2015, 17 years after treatment applications. Both carbon and nitrogen concentrations increased due to biosolids applications in 1998, and then decreased in 1999. Carbon concentrations then increased from 1999 to 2000 and from 2000 to 2015. Depending on tailings texture, nitrogen concentrations display increases or decreases between 1999 and 2000, and then increases between 2000 and 2015. This data provides insight into the long term trajectory of tailings ponds reclaimed with a one-time biosolids application. The current study supports the hypothesis that biosolids provide a long term benefit on mine tailings, and support a positive, self-sustaining trajectory.

25. PHENOTYPIC DIVERSITY WITHIN DOMINANT BLUE GRAMA GRASS ACROSS A PRECIPITATION GRADIENT.

Ava M. Hoffman*[1], Julie A. Bushey[1], Lynn Riedel[2], Troy W. Ocheltree[1], Melinda D. Smith[1]; [1]Colorado State University, Fort Collins, CO, [2]Boulder County Open Space and Mountain Parks, Boulder, CO

Droughts are expected to intensify in coming years with changing climate. It is imperative that ecologically and economically important native rangeland grasses, such as blue grama (*Bouteloua gracilis*) of the shortgrass steppe, be investigated for their phenotypic diversity across populations. We selected ten populations where blue grama was a dominant species across a precipitation and elevation gradient in Boulder County, Colorado, plus five sites along a larger north-south gradient. From each population, 17 clones were transplanted to controlled greenhouse conditions and subjected to two different watering regimes. When water limitation was removed, we observed extensive plasticity compared to field phenotype in all populations. However, we observed that more southern populations exhibited higher growth rates compared to northern and Boulder populations. We also considered differences in drought response strategy by comparing pre-dawn and midday leaf water potential, where we found populations to differ across the precipitation gradient in terms of anisohydric (passive) versus isohydric (active) water budgeting strategies. Finally, we observed differences in fitness (flower mass and length) across populations and clones. However, fitness did not vary by greenhouse drought treatment, suggesting potential tradeoff between clonal and sexual reproduction is specific to population or individual clones and not necessarily responsive to water availability. Elucidation of phenotypic diversity along with upcoming research highlighting genetic diversity across different populations of blue grama may inform

management and restoration practices in the shortgrass steppe ecoregion, as well as plant breeding programs.

26. WYOMING RESTORATION CHALLENGE: A PARTICIPATORY LEARNING COMPETITION. Beth Fowers*[1], Brian A. Mealor[2], Clay W. Wood[1], Rachel D. Mealor[2]; [1]University of Wyoming, Laramie, WY, [2]University of Wyoming, Sheridan, WY

Cheatgrass (*Bromus tectorum*) has impacted millions of hectares in the western United States. Many management tactics are available for cheatgrass, but a single, consistent approach that works in all areas and situations does not exist. In 2015, an area dominated by cheatgrass was divided into small plots and various teams accepted the challenge to restore their randomly-drawn plots with a primary goal of increasing knowledge and awareness of cheatgrass management and restoration options. To aid in this endeavor, each team is allowed to use any legal method to restore their plot to a diverse, productive rangeland that meets the goals of livestock grazing and wildlife habitat. This demonstration plot format allows for direct side-by-side comparison of different restoration practices and fosters friendly competition and engagement of professionals with general public as they interact informally and through structured educational opportunities. Treatments fit six general categories: fire, mechanical, chemical, seeding/competition, herbivory, and bacterial. Teams are evaluated according to cheatgrass reduction, vegetation productivity, species diversity, cost of implementation, scalability, and education and outreach efforts. Plots were monitored for canopy cover and species diversity summer of 2015 and 2016. Final evaluations and award decisions will occur in 2017. Beyond the management itself, teams have been able to learn, experience, and teach. Students have put class theories into practice and shared their experience with other students, professionals, and the general public. Land managers and extension educators have used their best knowledge and are sharing with others while enjoying the friendly competition. While successes and failures have occurred for different teams, the more important goal of education and awareness is being achieved as discussions occur during field days, various tours, meetings, and articles where knowledge and personal experiences are disseminated.

27. COMPETITION EFFECTS FROM CHEATGRASS (*BROMUS TECTORUM*) DIFFERS AMONG PERENNIAL GRASSES OF THE GREAT BASIN. Dan Harmon*, Charlie D. Clements; USDA-ARS, Reno, NV

Competition from the exotic annual cheatgrass (*Bromus tectorum*) threatens millions of hectares of native plant communities in the Great Basin. The Nature Conservancy has identified the Great Basin as the third most endangered ecosystem in the United States. Not only has increased fuels and fire frequency from cheatgrass invasion altered ecosystem biodiversity, the highly competitive nature of cheatgrass can also make management, restoration, and preservation attempts largely ineffective. The perennial

grass component of the plant community is key to resisting cheatgrass dominance. Seeding efforts and natural recruitment of native perennial grasses has been historically less successful than non-native rehabilitation grasses. To understand the discrepancy of success, we observed first-year growth (biomass) and survival of three native and one non-native rehabilitation perennial grasses in large outdoor non-irrigated soil containers using soils collected from three northwestern Great Basin USDA-ARS field sites. With cheatgrass as the single treatment factor, perennial seedlings were grown individually or with cheatgrass (6 plants) for one growing season. Growth of the non-native crested wheatgrass (*Agropyron cristatum*) decreased the least when competing with cheatgrass (30% decrease), while the native Sandberg blue grass (*Poa secunda*) had the largest decrease in growth (94%). Squirreltail (*Elymus elymoides*) and crested wheatgrass had a 25% decrease in survival from cheatgrass competition (80% survival without competition), while Sandberg bluegrass had the largest decrease in survival (60%). Bluebunch wheatgrass (*Pseudorogneria spicata*) survival was not effected by cheatgrass competition (30% survival with and without competition). Under non-competitive conditions, crested wheatgrass has been observed to have higher growth rates compared to the three native grasses and our results found that disparity was greatly magnified by cheatgrass competition. This study's results emphasize the importance of cheatgrass control to decrease competition prior to seeding efforts using tools such as herbicides, especially if a native-only policy is implemented.

28. USING THE LAWSON AERATOR FOR RANGE IMPROVEMENT PRACTICES. Charlie D. Clements*[1], John McLain[2], Dan Harmon[1], Jan Schade[3]; [1]USDA-ARS, Reno, NV, [2]Resource Concepts Inc, Carson City, NV, [3]Wildfire Conservation Group, Orovada, NV

Heavy duty implements designed and built for manipulating rangeland vegetation and soils to achieve desired results have been around for many decades. Rangeland drills were effective in reseeding severely deteriorated rangelands and creating effective seedings as early as the 1950's. Rangeland drills, brush hogs, Dixie harrows, tandem discs, land imprinters and other equipment have all played a part in treating rangeland environments. The Lawson Aerator is one of the newer implements to enter the scene for rangeland improvement. The Lawson Aerator shows great promise due to its ability to crush the heavy brush, reducing shrub canopies from 5-6' heights to 8-12", while also chopping the brush and aerating the soil. More productive sites with the presence of long-lived perennial grasses benefit from Lawson Aerator treatments as the perennial grasses are released and herbaceous component of the environment increase in density and vigor. Shrubs are not 100% controlled and the fall time treatment as some survive and even re-seeds big sagebrush (*Artemisia tridintata*) shrubs and improves the habitat by enhancing stand age structure and edge affect. The Lawson Aerator comes with a seeder or broadcast seeding attachment which is used for less productive sites as the habitat is seeded simultaneously with the shrub crushing activity and therefore, increases the density of perennial grasses through the recruitment of new seeded species seedlings. In central Nevada, prior to this mechanical treatment, the decadent big sagebrush cover was over 40% and the presence of desirable herbaceous vegetation was nearly absent,

1.3/m². By 2016 the habitat experienced more than a 200% increase in perennial grasses and the treated habitat was occupied by sage grouse (*Centrocercus urophasianus*), where two new strutting/lek (breeding) habitats were established through this range improvement practice. This innovative treatment has provided excellent wildlife and grazing values to the area.

29. THE USE OF FUNGICIDES, ABSCISIC ACID, AND HYDROPHOBIC COATINGS TO IMPROVE SAGEBRUSH SEEDING SUCCESS. Ryan Call*, Matthew Madsen, William C. Richardson, Thomas Bates; Brigham Young University, Provo, UT

The sagebrush steppe is undergoing rapid ecological change and the loss of sagebrush rangelands contributes to more than 350 species of animals and plants being listed as species of conservation concern, as well as, a decrease in recreational activities, reduced forage production, degraded water resources and an increase in fire frequency. In the sagebrush steppe, success rates for seeding are notoriously low. Current seed strategies do not address the potential limiting factors inhibiting the progression from seed to mature plant. Isolating and understanding these variables will allow us to focus on enhancement strategies designed to specifically target the issue. We propose the idea to find and address these limiting agents through seed enhancement technologies. Seed enhancement technologies allow for the physical manipulation and application of materials to the seed that can influence germination, emergence, and/or early seedling growth. We will present on strategies for minimizing seed loss to pathogens using fungicides and techniques for controlling seed germination timing with hydrophobic coatings and abscisic acid. The potential outcomes of these strategies can have significant impact on future seeding attempts by increasing overall success rates, which in turn can reduce overall costs.

30. POST-WILDFIRE LIVESTOCK GRAZING MANAGEMENT ON PUBLIC RANGELANDS IN NORTHEAST CALIFORNIA. Janyne M. Little*[1], Laura K. Snell[2], Elise S. Gornish[3], David F. Lile[1], Leslie Roche[3]; [1]UC Cooperative Extension, Susanville, CA, [2]University of California, Alturas, CA, [3]University of California, Davis, Davis, CA

Unprecedented wildfires are burning on federal lands used for summer grazing by livestock across California. As a result, ranchers and other stakeholders have concerns about proper livestock grazing policy and management for rangelands after fire. A typical approach to post-wildfire grazing policy is to issue a blanket requirement for two years of grazing cessation following a burn. Some have argued for longer rest time frames (up to 10 years), while others argue for no rest to reduce weed invasion and suppress fuel accrual. However, there is little to no scientific data to support either proposal. Some research has been conducted on grazing after relatively low severity prescribed fire, but little research has addressed grazing impacts after wildfire which commonly burn with much greater severity and during different seasons compared to managed prescribed fires. Here we estimate recovery trajectories of existing wildfire burned areas and develop key

indicators to assess rangeland readiness following fire using chronosequence methods. We selected 144 sites on 24 fires in northeast California that occurred within the last 15 years. After avoiding seeded or salvage logged areas, unburned areas, and overlapping fires, we account for the following variables: year from fire, grazing management, fire intensity, resistance/resilience classes, and broad vegetation communities. This research offers insight into how quickly rangeland health will recover as well as the amount of time allotments require to become ready to support livestock grazing without risk of long-term natural resource damage following wildfire.

31. ASSESSING AND MANAGING RANGELAND AND ENTERPRISE RESILIENCE USING AN INTEGRATED GRAZINGLAND ASSESSMENT METHOD. David Toledo*[1], Jeffrey Herrick[2], Sarah Goslee[3], Matt Sanderson[3], Gene A. Fults[4]; [1]USDA-ARS, Bismarck, ND, [2]USDA-ARS, Las Cruces, NM, [3]USDA-ARS, University Park, PA, [4]USDA-NRCS, Portland, OR

Shifts of rangelands into undesirable natural States (as described in State-and-Transition models) can be avoided using agronomic practices in order to maintain the function of rangeland ecosystems and thereby maintain the provisioning of goods and services from these areas. There is a need for a method that can be used to assess and optimize management of all grazinglands, including rangelands and pasturelands. We present an Integrated Grazingland Assessment methodology that uses Ecological Site Descriptions (ESD) and Forage Suitability Groups (FSG) descriptions to develop a standard for such grazingland evaluations. The Integrated Grazingland Assessment methodology takes the ecological strengths of the Interpreting Indicators of Rangeland Health methodology (Pellant et al. 2005) and combines it with the management optimization strengths of Pasture Condition Scoring (Cosgrove et al. 2001). By combining information found in ESDs and FSGs, this approach allows evaluators to assess site conditions and to make interpretations regarding management based on a standard method and site-specific attributes that can potentially optimize the ecological potential and livestock carrying capacity of a site. Standardized grazingland assessment and monitoring protocols based on ecological and land management principles can ultimately improve National level assessments, such as the National Resources Inventory, and will provide a valuable and efficient tool for assessing, managing and monitoring grazinglands.

32. RE-STOCKING OF GRAZING ALLOTMENTS POST WILDFIRE IN THE SOUTHWESTERN REGION OF THE USDA FOREST SERVICE. Judith Dyess*[1], George Ruyle[2], Amber Dalke[2], Ron Mortensen[3], Stephanie Coleman[3], David Evans[3], Michael Hannemann[4], Ed Holloway[5]; [1]USDA Forest Service, Edgewood, NM, [2]University of Arizona, Tucson, AZ, [3]USDA Forest Service, Springerville, AZ, [4]USDA Forest Service, District of Columbia, DC, [5]USDA Forest Service, Alpine, AZ

The Southwestern Region of the USDA Forest Service recognizes that rangelands evolved with a high degree of disturbance. These disturbances can produce critical changes in resource conditions. To avoid arbitrary decisions, it is often necessary to gather information quickly and perform an assessment of each allotment in order to adapt range management to allow for ecosystem recovery. The ability to adapt grazing management in response to changing conditions in the ecosystem is critical to the sustainability of rangelands and agricultural livestock production. In response to this knowledge in 2015, the Southwestern Region revised the Regional Supplement to the Grazing Permit Administration Handbook incorporating considerations for restocking and management of grazing allotments post wildfire and other disturbances. This poster will present those considerations.

33. THINNING IMPROVES FORAGE BIOMASS AND BOTANICAL COMPOSITION ON BRAZILIAN SEMIARID RANGELANDS. Ana Clara R. Cavalcante*[1], Jefte Arnon A. Conrado[2], Rafael G. Tonucci[3], Magno J. Cândido[2]; [1]Embrapa, SOBRAL, Brazil, [2]UFC, Fortaleza, Brazil, [3]Embrapa, Sobral, Brazil

Brazilian semiarid rangelands are characterized by low carrying capacity and overstocking, consequently a high proportion is under some degradation level. There is high potential to use these areas as pastoral ecosystems, but some technologies need to be applied in order to improve herbaceous forage biomass and, consequently, their carrying capacity. To measure the impacts of thinning on forage biomass and botanical forage species composition in Brazilian semi-arid rangelands, this work was carried out. During the wet season and the transition from wet to dry season, the total forage biomass (kg/ha) and the botanical composition were monitored in three areas: "Savanna" thinned rangeland, Layer thinned rangeland and a control area. A completely randomized block design with two replicates was adopted. Data was analyzed by ANOVA and means were compared by using Tukey test ($p<0.05$). Savanna thinned rangeland was efficient to increase in 33 times the total forage biomass (TFB) during wet season compare to control (59 kg/ha). This response was a benefit from some herbaceous species (*Arachis dardani, Phaseolus patyroides, Stylosanthes macrocephala, Anthephora Hermaphrodita*) that appeared in the Savanna thinned rangeland. During the transition season, the same behavior was observed. There were not season effects to Layer thinning compare with control. The TFB of the Layer thinned rangeland was two times higher than control (834 kg/ha). This management benefited the encroachment of the area with the forage species *Phaseolus patyroides, Centrosema pubescens e Anthephora Hermaphrodita*. Savanna or Layer thinning has improved the amount and quality of forage biomass, thus potentially increasing the animal output and the soil protection in Brazilian semiarid rangelands.

34. MECHANICAL CONTROL OPTIONS FOR COYOTE BRUSH ON CALIFORNIA'S COASTAL RANGELANDS.

Jeffery W. Stackhouse*[1], Sarah L. Dawe[2]; [1]University of California Cooperative Extension, Eureka, CA, [2]Natural Resource Conservation Service, Eureka, CA

Although native to California's coastal rangelands, *Baccharis* is perceived as a pest on ranches as continued fire suppression intensifies the species' foothold on historical grasslands. *Baccharis* encroachment reduces livestock production by limited forage access and availability. The goal of this study was to assess common mechanical removal techniques to determine the most effective, mechanical control option for coyote brush. *Baccharis* was cleared from 6 sites in spring of 2016 utilizing three treatment methods including track-type Caterpillar tractor (cat), a track-type excavator, and hand removal using a chain saw. Pre-treatment *Baccharis* mean cover was lowest on the saw removal units (52%), while cat and excavator treatment sites were similar with averages of 71% and 78%, respectively. Sites were monitored in the fall of 2016 to assess percent cover and frequency of *Baccharis* re-sprout post treatment. Results demonstrate that mechanical removal through the use of a large excavator was the most successful at removing this species and reducing resprouting (0.2% cover ($\pm$0.3)). Hand removal with chain saws was the most economically viable option for mature plant removal, but resulted in the greatest amount of re-sprouts at 6.3% cover ($\pm$2.0). The most time-efficient method was the use of a caterpillar tractor which resulted in 1.3% cover ($\pm$0.3), while retaining similar abilities of the saw treatment to traverse steeper slopes than the excavator. Results suggest that mechanical control of *Baccharis* using a track-type Caterpillar tractor is the most effective in coastal rangeland settings due to the control achieved, cost/time efficiency, and ability to maneuver in rough terrain.

35. COLLABORATIVE RANGELAND MONITORING IN NORTHERN ARIZONA.

Jeff W. Schalau*; University of Arizona Cooperative Extension, Prescott, AZ

The University of Arizona Cooperative Extension (UACE) has taught science-based rangeland monitoring techniques for over 20 years through workshops for ranchers, agency professionals, and interested members of the public. The UACE also provides leadership and personnel assistance to early adopting ranches to encourage neighboring ranches to initiate their own rangeland monitoring programs. The data collection methods are easy to learn, repeatable, and designed to minimize bias. Collaborative rangeland monitoring utilizes ranch personnel, agency professionals, and engaged volunteers to collect and discuss the data as a team. The following is a brief description of the collaborative rangeland monitoring at the Yavapai Ranch, near Seligman, Arizona.

The Yavapai Ranch is 110,000 acres of private (51%) and US Forest Service land. It ranges in elevation from 4,900 to 6,800 feet above sea level. Vegetation types include ponderosa pine forest, pinyon/juniper woodland, interior chaparral, and short grass prairie. The Yavapai Ranch has a Coordinated Resource Management Plan in partnership with multiple agencies. Each fall, the author coordinates between 15 and 25 people (CRM agency partners, students, and adult volunteers) to monitor rangelands for two

days. Of the 24 monitoring sites (called key areas), 6 are monitored each year and the data is processed and interpreted by the author and shared with participants. Data collected includes: frequency, cover, species composition, and landscape photos. Following data collection, a few variables are evaluated on-site and compared with prior data and discussed among participants. Other ranches have also participated and one has begun its own rangeland monitoring program as a result. Monitoring data has been collected yearly since 1994. Data is used to guide management decisions and monitoring participants are encouraged to provide management input. The Yavapai Ranch monitoring team has demonstrated that ranching in the west can be productive, collaborative, and sustainable.

36. COMPARISON OF NIRS AND RAMAN SPECTROSCOPY FOR PREDICTING BOTANICAL COMPOSITION OF CATTLE DIETS. Narangerel Altangerel[1], John W. Walker*[2], Piedad Mayagoitia[3], Derek W. Bailey[3], Gombojav O. Ariunbold[4], Marlan O. Scully[1]; [1]Texas A&M University, College Station, TX, [2]Texas A&M AgriLife Research, San Angelo, TX, [3]New Mexico State University, Las Cruces, NM, [4]Mississippi State University, Clarkville, MS

Near infrared spectroscopy of fecal samples (f.NIRS) has been shown to effectively predict botanical composition of diets of sheep and goats. However, because of the high absorbance in water bands and the effect of particle size feces have been dried and ground before collecting spectra. In contrast, Raman spectroscopy is an inelastic spectroscopy technique that is not affected by water and does not require sample preparation. The objective of this study was to compare f.NIRS to Raman for predicting the percentage of mesquite in cow diets and the discrimination of base rations by the two techniques. Fecal material was obtained from a feeding trial where known amounts of mesquite were introduced intraruminally into six ruminally fistulated cows with an average weight of 568 kg. Two animals were randomly assigned to one of three base rations, namely: timothy hay, Sudan hay or a 50:50 combination of Bermudagrass hay and beardless wheat hay. Fecal material was collected the last 2 days of four 7 day feeding periods where mesquite was fed at 0, 1, 3, and 5% of the base diet. NIR spectra of fecal material provided useful calibrations for predicting percentage mesquite in diets, but Raman spectra did not. Validation of f.NIR calibration using base diets containing Sudan or Timothy hays to predict percent mesquite in feces from base diets consisting of Bermuda and wheat hays had r2,slope and RMSE of 0.88,1.03 and 0.01, respectively. Cannonical discriminant analysis of wavelengths selected using a stepwise procedure showed that Raman and NIR spectra could classify the base hay ration for all the observations with 100% accuracy. The greater squared Mahalanobis distances between different base hay rations for the Raman spectra compared to the NIR spectra indicates that Raman spectra discriminated among the rations more efficiently than the NIR spectra.

37. SEED STORAGE EFFECTS ON GERMINATION OF TWO FORAGE KOCHIA CULTIVARS. Dan Harmon*, Charlie D. Clements; USDA-ARS, Reno, NV

The cultivar 'Snowstorm' forage kochia was released by the USDA-ARS in 2012. It is a synthetic cultivar selected for stature, forage production, and adaptation to semiarid environments. Similar to the earlier released (1984) 'Immigrant' cultivar it can increase rangeland productivity magnitudes when used for rehabilitation. The taller statured 'Snowstorm' has the advantage of providing critical protein for livestock and wildlife during winter months when the shorter 'Immigrant' may be covered by snow. 'Snowstorm' outperforms 'Immigrant' in most comparisons from forage production, protein content and digestibility. We conducted tests to observe the germination differences between the two cultivars for newly harvested, one year old and two year old seed with cold and non-cold storage. The seed set time for forage kochia (Oct-Nov) makes using newly harvested seed difficult because of winter conditions soon after harvest time. Often one year old seed is the only option to use before winter conditions. One year old non-cold storage 'Immigrant' kochia seed has shown low seed viability. Seeding often requires cold storage seed and increased costs. Using 55 different constant and alternating temperatures representative of Great Basin seedbed temperatures, we tested germination of the two cultivars for fresh, one and two year old seed from cold or non-cold storage. Fresh seed had equal germination between cultivars ('Snowstorm' mean:30%, max:62%, 'Immigrant mean:30%, max:60%). After one year of cold storage (7C) 'Snowstorm' kochia remained viable with 30% mean germination (max:53%), while 'Immigrant' decreased to 4.5% mean (max:17%). Seed stored under non-cold conditions (seed storage shed temperature mean:20C, max:44C) showed a decrease in germination for both cultivars ('Snowstorm mean:17%, max:39% and 'Immigrant' mean:2.6%, max:11%). Second year storage results will be reported after finalized germination tests. This study supports observations of improvements for the cultivar 'Snowstorm' and the need for increased seed supplies, rangeland rehabilitation, and research use.

38. HYDROPHOBIC SEED COATINGS FOR IMPROVING RANGELAND RESTORATION: FALL RE-SEEDING. Karma Phillips*, Dallin Whitaker, Rebecca Schenk, Matthew Madsen; Brigham Young University, Provo, UT

Rangeland reseeding is a strategy often employed by land managers to improve rangelands after disturbance. Reseeding is carried out during the fall season in an effort to avoid unfavorable environmental conditions in the field (i.e. summer-drought/winter-freezing). Reseeding however, has high failure rates because of an increased mortality of seedlings during freezing events. Throughout a typical winter season, a seed must survive <60 freeze-thaw cycles. Various applications have been developed to aid in preventing high mortality rates of seedlings during such conditions. We've developed a new application with the intent to protect against freezing by preventing early imbibition and germination of seeds through the use of a hydrophobic seed coating. Preliminary, research appeared to show that in some instances the hydrophobic coatings would prematurely breakdown due to freeze cycles and allow germination to occur during the winter. Our research explored options to enhance the integrity of a hydrophobic coating

under repeated freeze-thaw events to allow for breakdown in late winter/early spring so that germination occurs when soil temperatures are more conducive for seedling survival. Research was divided into three main studies: 1) evaluation of ethylcellulose products for use as a seed coating and chemical plasticizers that could be applied with the hydrophobic coating material, 2) we explored how application rates of these products influenced resistance to freeze-thaw events, 3) we will use two models to predict seed germination: the time to hydrophobic coating failure model and the hydro-thermal accumulation model. The coating-failure model will illustrate when temperature and moisture begin affecting germination and the hydro-thermal model will give an actual date of germination after coating failure. Together, these two models are applied to historical temperature and moisture data to predict seed germination for various sites. This technology will enable land managers to continue reseeding efforts and increase rangeland reseeding success.

39. DEVELOPMENT OF A PLANT-SOIL-WATER (ECOHYDROLOGY) MODEL TO AID IN RANGELAND MODELING USING SYSTEM DYNAMICS. Benjamin Turner*; Texas A&M University-Kingsville, Kingsville, TX

Systems analysis has aided in analyzing and predicting the impacts of various management strategies to many rangeland issues, including grazing effect on annual net primary production, animal health (e.g., livestock body condition scores), ranch profitability (i.e., from alternative stocking rates), or wildlife populations (e.g., interaction between climate and harvest strategies). Based on previously published models, evidence suggests that rangeland models could be enhanced through incorporation of ecohydrologic concepts, particularly as it relates to forage supply and water balance on rangelands. Previous rangeland models 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 or wildlife through changes in range condition, irrespective of changes in plant community composition. On the other hand, ecohydrology models have focused on the importance of soil texture and the basic water-balance equations to model infiltration, excess runoff, and changes in plant community composition through changes of evapotranspiration, which is partly driven by available soil moisture. By combining approaches, rangeland models could account not only for grazing impacts on production and profitability, but also the impacts to site-specific hydrologic function, which should prove useful given uncertain climate changes and increasing awareness of ecosystem goods and services. In this poster, I present a simple plant-soil-water model created in Stella™ (iSeeSystems, Lebanon, NH) that illustrates how ecohydrology concepts could be incorporated to new or existing rangeland models. The model is calibrated to observed data from four locations of diverse soil properties and climate characteristics in Texas (Seymour, Palestine, San Marcos, and Edinburg; TAMU North America Soil Moisture Database). Early diagnostic and sensitivity tests will be presented. Lastly, some model limitations are described along with directions of future work.

40. EVALUATION OF THE NEBRASKA GRAZING LANDS COALITION RANGELAND MONITORING PROGRAM. Mitchell Stephenson*[1], Ben Schiltz[1], Ron Bolze[2]; [1]University of Nebraska - Lincoln, Scottsbluff, NE, [2]Nebraska Grazing Land Coalition, Chadron, NE

The Nebraska Grazing Lands Coalition developed a rangeland monitoring program (RMP) to assist land owners in developing range monitoring programs on their grazing lands. As part of the program, producers voluntarily signed up to have a range technician come to their ranches to teach them how to set up a monitoring program, discuss current grazing management, and provide range monitoring equipment at a minimal cost. In the first 6 years of the program 320 land manager have participated in the monitoring program. Surveys were sent to 230 of the past RMP participants with the objective of determining how beneficial this program was in helping producers better monitor their rangelands. Seventy participant surveys were returned (30.4% response rate). Survey participants managed approximately 20,000 animals on over 200,000 acres of range and pastureland. Eighty-six percent of participants indicated that they had continued monitoring following the initial training. Nearly 90% of the participants that said they continued monitoring conducted photo monitoring. Seventy-one percent of survey participants indicated the RMP gave them a greater understanding of rangelands and was a catalyst in changing their grazing management. Many (84 %) of the participants indicated that the RMP and monitoring has helped them better visualize their rangelands and make adjustments in management. The RMP program has improved grazing management on many ranches in Nebraska and has increased awareness of grazing management issues.

41. COLD DESERT VEGATATION RESPONSE TO 35,000 YEARS OF CLIMATE CHANGE: A FUNCTIONAL PLANT TYPE ANALYSIS. Robin J. Tausch*[1], Robert S. Nowak[2], Cheryl L. Nowak[2]; [1]Rocky Mountain Research Station, Retired, Reno, NV, [2]University of Nevada, Reno, Reno, NV

Functional plant type abundance for trees, shrubs, grasses, and forbs representing 154 plant taxa from 52 woodrat midden strata were used to study vegetation/climate relationships in western Nevada. Sampled middens were from mountainous terrain with a range of topographic conditions covering 800 m in elevation and the last 35,000 years. Six time periods were identified, each with relatively stable climatic conditions and vegetation composition. Significant changes in climate and vegetation composition occurred during five rapid transitions between the six time periods. During three of these transitions (26.0 kCY, 13.5 kCY, 0.55 kCY) the rapid changes in climate included decreases in temperature. For the remaining two transitions (15.0 kCY, 8.0 kCY) the rapid changes in climate included increases in temperature. These changes represent a long-term cyclic pattern for climate and vegetation not previously described for the western Great Basin. As the temperature rapidly decreased during the transitions at 26.0 kCY and 13.5 kCY herbaceous taxa dominance significantly increased. During the

transitions where temperature rapidly increased shrub dominance increased. The largest changes in vegetation composition occurred during the rapid increase in temperature at the 15.0 kCY transition. This included both a significant increase in shrub abundance and composition, and a significant decrease in forb abundance and composition. A significant decline in forb abundance that occurred with the increase in temperature at the 8.0 kCY transition further reduced herbaceous dominance. Shrub dominance is now at its highest level, and herbaceous dominance at its lowest level, for the last 35,000 years. These trends in increasing shrub and decreasing herbaceous dominance after 8.0 kCY appear to have provided increased opportunities for the invasion and dominance of exotic plant species. With the temperature increases projected to occur over the rest of this century expansion in exotic dominance can be expected to continue, and even increase.

42. EVALUATION OF FECAL NEAR INFRARED SPECTROSCOPY CALIBRATIONS FOR SHEEP AND GOATS CONSUMING ARIZONA RANGE FORAGES. Douglas R. Tolleson*[1], Sophie Leone[2], Lisa Page[3], Carmen McConnel[2]; [1]Texas A&M University, Sonora, TX, [2]The University of Arizona, Tucson, AZ, [3]The University of Arizona, Camp Verde, AZ

Near infrared spectroscopy of feces (FNIRS) has been used to monitor diet quality and composition in free-ranging livestock and wildlife. Current FNIRS calibrations have been typically developed and applied within a single herbivore species. We hypothesized that domestic livestock could be used as surrogates to develop FNIRS diet quality calibrations for application in wild herbivores. FNIRS calibrations developed for sheep (*Ovis aeries*), goats (*Capra hircus*), and elk (*Cervus elaphus*) were used in an experiment designed to determine differences in near infrared spectra of feces and predicted diet crude protein (CP) of sheep and goats fed plants commonly found on rangelands of Arizona. Five Barbado ewes (29.2 ± 1.8 kg) and 5 Spanish/dairy cross does (20.8 ± 0.8 kg), were pair-fed 10 diets consisting of various combinations of native grass/forb hays, supplemented with alfalfa (*Medicago sativa*) as needed to achieve a range in CP from approximately 5-17%. All animals received a common pre-trial adaptation diet of mixed native grass hay for 7 d. Each experimental diet was fed AM and PM to each sheep and goat pair for 7d. Fecal samples (n = 140) were collected at feeding times on d 6 and 7. Spectra (400-2500nm) were obtained on fecal samples and diet CP was predicted using existing sheep, goat, and elk FNIRS calibrations. Mahalonobis distance (GH) values were calculated for fecal spectra. Differences in CP and GH values were determined by analysis of variance. FNIRS-predicted diet CP was 16.0 ± 0.4, 13.8 ± 0.4, and 7.9 ± 0.3 for fecal samples predicted with the sheep, goat, and elk calibrations respectively (P < 0.01). Similarly, GH values were 4.0 ± 1.2, 5.8 ± 1.4, and 17.7 ± 0.3. FNIRS can be used to monitor diet CP across animal species, but expansion of the FNIRS calibrations should improve predictive ability.

43. BIOMASS ACCUMULATION OF IMPORTANT GRASS SPECIES OF THE TEXAS RANGELANDS. LEOBARDO RICHARTE*[1], Carlos Villalobos[2]; [1]Texas tech University, LUBBOCK, TX, [2]Texas tech university, Lubbock, TX

Understanding biomass accumulation patters is very important to design appropriate grazing strategies according to grass morphological types. Our objectives were to identify biomass allocation patterns in important grass species of Texas rangelands on grass structures (aboveground, crown and roots). This study was conducted from May to October 2016 under field conditions at the Texas Tech University Native rangeland. This area has dry steppe climate with mild winters. Mean annual precipitation is 481 mm (Southern Regional Climate Center 2015). Vegetation on the area consists of mid and shortgrass species. (Bradbury 2007). Grass species used in this study were three native grasses: switchgrass (*Panicum virgatum L.*) cultivars Alamo and Kanlow, blue grama (*bouteloua gracilis*) and side-oats grama (*Bouteloua curtipendola*), finally, an introduced species: WW-B.Dahl [Bothriochloa bladhii (RETZ) S.T. BLAKE) which is used in improved pastures due to its dry tolerance and great biomass production. Grasses were established on 5 gal nursing pots, with one plant per pot. Plants were located in the field and irrigated according to the mean annual precipitation. Plant biomass was collected at the end of the growing season and divided up into three components: aboveground, crown and roots. We used a CRD design, being species our treatment and analysis of variance to look at differences in biomass production of each biomass component among grass species. Statistical analysis showed significant differences in biomass production for each biomass component among grass species. Alamo switchgrass was the species that produced the higher biomass amount in each component, almost twice the amount of intermediate producers such as WW-B.Dahl and Kanlow being side-oats grama and blue grama the ones that produced the lower biomass values. However, although kanlow produced a low aboveground biomass it tended to produce higher roots biomass than the other species. In general terms, we can say that all these grasses produced slightly more belowground biomass that aboveground biomass.

44. MONITORING DIET QUALITY AND PREDICTING ANIMAL PERFORMANCE IN RANGE CATTLE WITH FNIRS AND NUTBAL. Rachel J. Turner*[1], George Ruyle[1], Douglas Tolleson[2]; [1]University of Arizona, Tucson, AZ, [2]Texas A & M University, Sonora, TX

Range cattle grazing in arid and semi-arid regions are commonly limited by lack of nutrients from low-quality forage. Due to this, managers are faced with the challenge of monitoring diet quality in order to address nutrient limitations. Near-infrared spectroscopy of fecal samples (fNIRS) is a method used to determine diet quality in grazing animals. When combined with a nutritional balance analyzer such as the NUTBAL system, fNIRS can be used to monitor nutritional status and predict animal performance. In addition, previous research has shown that forage intake and forage quality are positively correlated. Our research aims to test the ability of NUTBAL to predict animal performance as represented by body condition score in cattle grazing on the Santa Rita Experimental Range in southern Arizona. This research also aims to

determine the relationship between available forage and diet quality. Beginning in June of 2016, body condition score and fecal samples were collected from the Santa Rita Ranch's registered Red Angus herd (n=82 AU). During the midpoint of the grazing period in each pasture, 30 body condition scores and a fecal composite of 15 samples were collected. Additional opportune samples are gathered during periods of expected nutrient stress. Vegetation sampling includes estimates of standing biomass and botanical composition before the herd enters a pasture. After the herd exits each pasture, herbaceous utilization is measured and browse use is determined. Diet crude protein was 6.01%, 4.31%, and 5.86% on June 10, June 24, and July 13 respectively. We hypothesize that cattle diet quality is positively correlated to available forage and that body condition score can be accurately predicted through the use of fNIRS coupled with NUTBAL. With this information, cattle managers in southern Arizona can better address nutrient deficiencies of grazing animals.

45. CONSUMPTION OF TALL LARKSPUR (*DELPHINIUM OCCIDENTALE*) BY RESISTANT AND SUSCEPTIBLE CATTLE. Jim Pfister*[1], Ben Green[1], Daniel Cook[2], Kevin Welch[1], Dale Gardner[1], Clint Stonecipher[1]; [1]USDA-ARS, Logan, UT, [2]USDA ARS, Logan, UT

Larkspurs (*Delphinium* spp.) are a major cause of cattle losses on western ranges in North America, especially on foothill and mountain rangelands. Previous work in our laboratory has shown that there are substantial breed and individual animal variations in response to a standard dose of larkspur alkaloids. Susceptible and resistant animals differ substantially in their response to larkspur alkaloids, and this response has a genetic basis as determined from DNA genotyping. Within the Angus breed, we screened steers to provide groups of resistant and susceptible animals (n = 6/group). Steers were phenotyped by dosing with larkspur and measuring exercise tolerance. Phenotyped steers were grazed on a larkspur-infested rangeland (*D. occidentale*) in southeastern Idaho during summer for 2 years (2015 and 2016). Different steers were used each year. Susceptible animals initially consumed about 2x more larkspur than did resistant animals both years, provoking serious symptoms of intoxication in susceptible animals. One susceptible steer died in year 2. However, by the end of the year 1 trial, there were few differences in larkspur consumption between resistant and susceptible cattle. During year 2, in the latter portion of the second grazing trial, resistant steers consumed about 2x more larkspur than did susceptible steers; resistant steers showed clinical signs of poisoning, but had no fatalities. Serum alkaloid concentrations > 500 ng/mL always resulted in muscular paralysis and collapse. Results to date suggest that selection of larkspur by steers with different responses to poisoning is dynamic and may not be predictable based on phenotype. These results also indicate the increased risk of fatal intoxication in susceptible cattle compared to resistant animals while grazing larkspur-infested rangelands.

46. EFFECTS OF SUPPLEMENTATION STRATEGY ON HEIFER RESOURCE UTILIZATION AND DORMANT VEGETATION USE OF MONTANA RANGELANDS.

Samuel A. Wyffels*[1], Lance B. McNew[1], Mark Petersen[2], Janice G. Bowman[1]; [1]Montana State University, Bozeman, MT, [2]USDA-ARS, Miles City, MT

In Montana, economic efficiency of cattle production is threatened by high feed and input costs. To improve profitability and reduce reliance on harvested feeds, many cow-calf producers have adopted management strategies involving dormant season grazing. Providing supplements to grazing beef cattle during times of low forage quality may improve animal performance and vegetation utilization across the landscape. However, information relating supplementation strategies to individual grazing behavior and resource utilization on dormant forage is lacking. Thus, the intent of this research is to examine cattle resource utilization, residual cover of vegetation and utilization on rangelands grazed during the dormant season under two supplementation management strategies. Appoximately 100 weaned composite heifer calves were randomly selected and placed into one of two supplementation treatments (50 heifers/treatment); one recieving a free access 62% crude protein self-fed mineral/protein concentrate, and the other recieving a daily hand-fed 20% crude protein cake fed in bulk. Grazing for both treatments occurred simultaneously beginning in December 2015 and continued through March 2016. Thirty transects were randomly located within each pasture for measuring vegetation composition, production and quality, canopy cover and visual obstruction readings pre and post grazing. Grazing locations were monitored for seven individuals within each treatment with Lotek GPS collars containing head position sensors that record daily space use as well as timing and location of grazing activities at 5 minute intervals. New individuals were selected for GPS collars every 28 days. Data sets were used to quantify space use as a continuous, probabilistic variable and related to the habitat covariates using multiple regression in a resource utilization function analysis. This research will address comprehensive agro-ecosystem responses of dormant season cattle grazing and protein supplementation while providing multidimensional insight to stakeholders concerning grazing behavior and the ecological impacts of late season use on Montana rangelands.

47. INFLUENCE OF BIOLOGICAL SOIL CRUSTS ON GRASS GERMINATION AND ESTABLISHMENT OF NATIVE AND NON-NATIVE GRASSES .

Cheryl L. McIntyre*[1], Steven Archer[1], Jayne Belnap[2]; [1]University of Arizona, Tucson, AZ, [2]U.S. Geological Survey, Moab, UT

Biological soil crusts (biocrusts) typically cover open spaces on soils in arid and semi-arid regions globally. Biocrusts can have positive, negative, or neutral effects on vascular plant germination. We are conducting complimentary experiments (field and semi-controlled environment) to determine if grass seed morphology (e.g., size, shape, mass and appendages) interacts with biocrust characteristics (e.g., species composition, microtopography, and integrity) to differentially affect the germination and establishment of native and non-native grasses. Our experiments are being conducted on the Colorado Plateau, where biocrusts are pinnacled, and in the Sonoran Desert, where biocrusts are

comparatively smoother. Standardizing for seed viability, germination/emergence of warm-season grasses in the Sonoran Desert show higher mean (± SE) emergence among seeds placed in fissures of biocrusts or soil stabilizing polyacrylamide gel (PAM) crusts (53% ± 3) compared to seeds placed on the surface of intact crusts (22% ± 1). Fissure-placement effects may be biotic, abiotic, or a combination. Emergence was also significantly higher on broken PAM crusts and biocrusts (34% ± 2) compared to intact crusts. Cool-season grasses in the Sonoran Desert show similar trends. Autumn establishment trials on the Colorado Plateau show that cheatgrass was more likely to establish (mean ± SE) on bare soil and PAM crusts (18% ± 2) when compared to cyanobacteria or lichen biocrusts (10% ± 1). Cheatgrass was also more likely to establish in disturbed PAM crusts and biocrusts (18% ± 2) compared to intact crusts (7% ± 1). Experiments with seed awns intact and removed are being conducted to determine the effect of appendages. Manipulation of seed appendages is part of our goal to understand if there are seed characteristics that might predict which grasses are more likely to establish on biocrusts and if those characteristics differ between native and non-native grasses.

48. ADAPTIVE MANAGEMENT FOR RESTORATION OF UTAH JUNIPER WOODLANDS. Douglas Johnson*[1], James N. Long[2]; [1]Utah National Guard, Bluffdale, UT, [2]Utah State University, Logan, UT

Utah juniper is a key habitat for training soldiers of the Utah National Guard at Camp Williams. Where some land management agencies are clearing juniper, we value it for concealment in an otherwise sparsely covered landscape. In 2012, a single wildfire consumed about half (1,100 acres) of all juniper on the camp (~2,500); much that was the most accessible for training. Past establishment of juniper has been unsuccessful; losing all 1,500 seedlings in an especially droughty summer. Theorizing that a site-specific ecotype might be more successful, we collected 30,000 berries at the camp and commissioned the USFS Lucky Peak Nursery to grow seedlings. Production from the site-specific berries was poor because of low seed viability; just over 1,300 seedlings were planted in early April 2016. 10% were marked for follow-up and another 10% were supplemented with Dri-Water (which provides about 90 days moisture) in early summer to see if survival increased. The inital effort cost about $7.70 each due to low seedling production; the Dri-Water added about $4.00 each with labor. As of October 2016, inital estimates are about 50% survival without Dri-Water, but over 90% with Dri-Water. Future efforts will include planting in Fall, possibly using commercially-obtained stock if available, and supplementing with Dri-Water or providing other moisture.

49. ACTIVITY BUDGETS OF RANGELAND CATTLE WITH DIVERGENT MOLECULAR BREEDING VALUES FOR RESIDUAL FEED INTAKE . Carly A. Moore*[1], Nicky Lansink[1], John Basarab[2], Carolyn Fitzsimmons[3], Scott Nielsen[1], Graham Plastow[4], Edward Bork[1]; [1]University of Alberta, Edmonton, AB, [2]Alberta Agriculture

and Forestry, Lacombe, AB, [3]Agriculture and Agri-Food Canada, Edmonton, AB, [4]Livestock Gentec, Edmonton, AB

Activity is a component that has been found to contribute 10% to the biological variation of residual feed intake (RFI) in cattle, even in feedlots. Greater cattle activity may be expected within cattle on pasture due to the ongoing search for high quality and quantity forage and water sources, and the need to regulate exposure to environmental variables (e.g., insects, wind, and temperature). These behaviours inevitably influence animal maintenance costs. The objective of this study was to test whether cattle with divergent RFI as determined by molecular breeding values (MBV) have different activity levels on pasture.

Research was conducted at the University of Alberta Mattheis Research Ranch, 35 km north of Brooks, Alberta in the Mixedgrass Prairie. An identified subset of commercial cows with distinctly divergent (high and low) molecular breeding values for RFI were fitted with AfiAct II pedometers to track their activity (lying, standing and movement time, lying bout, movement rate) while rotationally grazing a series of large pastures over a period of five months. Data were separated into season (native grassland growing, cultivated, wetland, and native grassland dormant) for comparisons and analysis. Preliminary activity data show both high and low RFI animals spend up to 80% of their time standing or lying down. There appear to be trends of reduced movement within the dormant season compared to all other pasture seasons. Statistical analysis of activity for each RFI group and implications of the results for rangeland managers will be shared in this poster.

Symposium:
Southern Rockies Fire Science Network – Outreach and Applied Research

THE SOUTHERN ROCKIES FIRE SCIENCE NETWORK: ADAPT TO THE GAPS IN WILDFIRE KNOWLEDGE . Gloria J. Edwards*; Southern Rockies Fire Science Network, Fort Collins, CO

How We Help You: The Network is a service providing innovative ways for managers, scientists, policy makers, and citizens to interact and share both fire science and on-the-ground knowledge on important management topics throughout intermountain Colorado, southern Wyoming, eastern Utah, and the Black Hills of South Dakota/Nebraska. This region is characterized by management issues involving smoke and air quality, Fire adapted communities and fire response, fuels management and effectiveness, landscape restoration and resilience, and sagebrush and fire. We are a catalyst for wildfire science and exchange between interested and involved groups through an inclusive and open process helping researchers, managers, and communities make sound decisions on wildfire issues based on credible science. With over 900 followers and growing, the Network is the only regional organization focused on fire science information and exchange across agency, administration, and state boundaries. To join us:

- Submit a "mini-grant" proposal for an event or product through our website: www.southernrockiesfirescience.org .
- Attend a field trip, workshop, webinar, or read and share materials on our website, bi-weekly E-News, Twitter, Facebook, and YouTube.
- Contribute to regional understanding and communication of wildfire issues by sharing your projects, research, stories, and questions through our social media.

PLANT COMMUNITIES IN A SHRUBLAND-GRASSLAND ECOTONE REVEAL LASTING EFFECTS OF WILDFIRE AND INTERGRADING ECOLOGICAL SITES.
Lauren Porensky*[1], David Pellatz[2], David J. Augustine[1], Justin D. Derner[3]; [1]USDA-ARS, Fort Collins, CO, [2]Thunder Basin Prairie Grasslands Ecosystem Association, Bill, WY, [3]USDA-ARS, Cheyenne, WY
Wildfire can promote productivity and biodiversity in some locations, but in other locations this same disturbance can cause catastrophic ecosystem shifts. In many regions, including the shrubland-grassland ecotone of northeast Wyoming, the role of wildfire remains unclear. A better understanding of how rangeland ecosystems respond to wildfire will enable better management of these systems for multiple objectives, and can also improve our understanding of ecological sites, which are partially defined as areas that respond similarly to natural disturbances. We asked how wildfire influences plant community composition in northeast Wyoming, and whether wildfire operates differently across different ecological sites. In 2014, we sampled plant community composition at 73 pairs of burned and unburned transects across 30 wildfires that burned from 1937-2012. Transects were paired based on grazing allotment, ecological site, slope, aspect, elevation and topographic wetness index. We used nonmetric multidimensional scaling ordination to investigate variability in plant community composition. Wildfires induced long-term community shifts, and these shifts were consistent across ecological sites. Compared to unburned transects, burned transects had <10% as much shrub cover, 15% more perennial grass cover, and a different group of dominant forbs. Time since fire had surprisingly weak effects on plant community composition. Long-term losses of shrubs from burned sites may be problematic for managers attempting to maintain sagebrush habitat for sage grouse (*Centrocercus urophasianus*) and other wildlife species. Conversely, increased cover of perennial grasses in burned sites suggests that these areas may provide important forage resources. Plant community composition was not strongly associated with ecological site, but varied continuously along gradients defined by surface soil texture, geographic position, and landscape position. Together with the wildfire response data, these results suggest that ecological sites in this region could reasonably be simplified into two or three categories, with a recognition that gradients exist within these broad classes.

PUTTING THE FIRE IN A BOX; EMERGING FUEL TREATMENT ALTERNATIVES. Darren McAvoy*; Utah State University Forestry Extension, Logan, UT

Fire use is critical to managing western landscapes, however there are emerging alternatives to open burning that may be useful to range and forest managers. This talk will introduce the basics of pyrolysis and torrifaction as a means to reduce fuel loading in wildland and urban settings. Since 2010, the Utah Biomass Resources Group (UBRG) has been addressing this problem with the development and application of gasification and pyrolysis technologies. We have identified appropriate technologies and worked with Amaron Energy and others to make this technology mobile and appropriately scaled. The UBRG has also begun to investigate the efficacy of various low cost mobile pyrolysis kilns, these will also be introduced in this session.

PRESCRIBED BURNING IN UTAH AND WYOMING SAGEBRUSH ECOSYSTEMS AND IMPLICATIONS FOR SAGE-GROUSE. Eric T. Thacker*; Utah State University, Logan, UT

Prescribed burning in sagebrush ecosystems has been used as a form of brush control for decades. However, more recently prescribed fire has been scrutinized because of concerns over negative impacts to sagebrush obligates such as sage-grouse. The role of fire in sagebrush systems is complex and often oversimplified. Sagebrush response to prescribed fire varies due to biotic and abiotic factors that vary widely in sagebrush ecosystems. To add to the complexity of these responses, sage-grouse respond differently to fire depending on which habitat is impacted. For example, the use of prescribed fire in breeding habitats has been shown to have a negative impact on sage-grouse populations. However, there have been some instances of fire having a positive impact on late brooding rearing habitats. Future use of prescribed fire in sagebrush systems is tenuous and will require managers to consider the ecological role of fire rather than viewing fire as a management tool. This presentation will identify the potential use and limitations of prescribed fire in sagebrush systems and the impacts to sage-grouse.

RESILIENCE AND RESISTANCE CONCEPTUALIZED TO MANAGE THREATS TO SAGEBRUSH-ECOSYSTEMS AND SAGE-GROUSE IN THEIR EASTERN RANGE. Jeffrey L. Beck*[1], Jeanne Chambers[2]; [1]University of Wyoming, Laramie, WY, [2]Rocky Mountain Research Station, Reno, NV

Persistent ecosystem and anthropogenic disturbances and stressors are threatening sustainability of sagebrush (*Artemisia* spp.) ecosystems in the western United States, and managers and policy makers are seeking strategic, holistic approaches for species conservation and ecosystem restoration. Recent research indicates that an understanding of ecosystem resilience to disturbance and resistance to nonnative invasive species can be used to prioritize management activities across large landscapes and determine the most appropriate actions at project scales. An interagency working group of the Western Association of Fish and Wildlife Agencies has linked this understanding with breeding habitat probabilities for greater (*Centrocercus urophasianus*) and Gunnison sage-grouse (*C. minimus*), and developed a habitat decision matrix for assisting land managers in best

allocating resources. This approach was incorporated into the Subregional Greater Sage-grouse Environmental Impact Statements and served as the basis of a U.S. Department of Interior (DOI)-Bureau of Land Management Fire and Invasives Assessment Tool which was used to prioritize sage-grouse habitat for targeted management activities in the Great Basin. Recently a similar approach has been developed for Gunnison sage-grouse and the eastern range of greater sage-grouse–the Sagebrush Management Resilience and Resistance Tool (SMRRT). A 2015 Implementation Plan for DOI Secretarial Order 3336–Rangeland Fire Prevention, Management and Restoration–provides necessary guidance to ensure application of this approach.

WILDFIRE AND PRESCRIBED FIRE FUNCTION IN WYOMING: BIG GAME, VEGETATION, AND SOCIAL RESPONSES. John D. Scasta*; University of Wyoming, Laramie, WY

Wyoming is one of the driest, coldest, and highest elevation states in the conterminous United States and where the Great Plains meet the southern Rockies. Consequently, fire functions variably across gradients of topography, precipitation, and plant communities with estimated pre-European fire return intervals ranging from 6 to 15 years in the northern mixed grass prairies, 16 to 30 years in the ponderosa pine-shrub-grass plant communities, 60 to 125 years in the sagebrush steppe, and > 125 years in the sub-alpine forests. Currently, partners at the University of Wyoming, Bureau of Land Management (BLM), United States Forest Service, and private ranchers are conducting applied research to assess how fire can be restored to optimize habitat for big game while avoiding collateral damage of additional plant invasion. In 2014, BLM conducted prescribed burns in ravines dominated by aspen (*Populus tremuloides*) and serviceberry (*Amelanchier alnifolia*) (re-sprouting shrub species) and paired (burned/unburned) game cameras were established to capture large ungulate responses the following growing season. There were consistently more elk images captured in burned areas across all the camera pairs but results were variable for mule deer and pronghorn. It appears that elk were spending more time foraging in burned areas while mule deer and pronghorn were typically traveling through unburned areas. In another project, we have measured rabbitbrush (*Chrysothamnus viscidiflorus*) response to a 2010 wildfire in sagebrush steppe due to rancher concerns that fire led to rabbitbrush invasion yet ranchers desire to use prescribed fire to manage sagebrush dominance. Our results indicate that proportional density of rabbitbrush was unchanged post-fire but the reduction of sagebrush led to enhanced visibility of rabbitbrush in the understory. Thus, fire is an important disturbance in Wyoming that can be manipulated to alter big game distribution and structure of plant communities but additional research is a perennial need.

COLLABORATIVE APPROACHES FOR FIRE-RESILIENT LANDSCAPES. Tony Cheng*; Colorado State University, Fort Collins, CO

Reducing the size and severity of wildland fires through vegetation management treatments (e.g., mechanical or manual vegetation removal, prescribed fire) is a high priority for land and natural resource managers, policy-makers, resource users, and public stakeholders. However, it is neither desirable or feasible to conduct treatments across an entire landscape due to legal, regulatory, budgetary, societal, and operational constraints. Collaborative processes involving managers and a broad range of stakeholder interests are being used across the US West to strategically prioritize where to reduce the severity of fire effects to values of concern, and where to allow fire to operate as a critical ecological process. This presentation identifies six core collaborative 'action arenas' for advancing fire-resilient landscapes and will highlight how these principles have been applied on the Uncompahgre Plateau in western Colorado as an illustrative example. The six action arenas include: organizing participants; enabling learning opportunities and activities; making decisions about management objectives and appropriate actions; coordinating and resourcing implementation actions; monitoring effects; evaluating outcomes relative to objectives; and legitimizing collaborative efforts by cultivating public and political support. Four factors affecting collaboration will also be discussed, including: supportive policies, committed leadership, willingness of participants to work towards collaborative solutions, and boundary-spanning individuals, structures, activities, and objects.

UNDERSTANDING AND PREDICTING CONSEQUENCES OF FIRES ACROSS COLORADO AND WYOMING AND TWO NATIONAL FORESTS. Bryn D. Marah*, John D. Scasta; University of Wyoming, Laramie, WY

Wildland fire is a dynamic system that sparks considerable global interest. Regionally, Colorado and Wyoming are western states in the southern Rocky Mountains of the US that experience both prescribed and wild fires annually. Fire is an ecological and social feature of both states that varies across dominant vegetation types, environmental drivers, and social perspectives. Evidence suggests that future fire regimes may include more frequent and intense fires. Moreover, federal agencies are increasingly aware of the need to strategically allow fire to function while continuing to protect life and property. The Grand Mesa, Uncompahgre and Gunnison forest in Colorado and Medicine Bow-Routt National Forest in Colorado and Wyoming experienced several fires in the year of 2016 including the Kelso Fire (Colorado), Beaver Creek Fire (Colorado and Wyoming), and Broadway Fire (Wyoming). The Beaver Creek Fire was highly complex due to the overlap of jurisdictional boundaries, surface ownership, fire weather, acres burned, and cost of the incident. The Storm Peak Wildland Fire Module allowed us to incorporate real time and pre-burn data and footage into our post-fire sampling regime at both the Beaver Creek and Kelso Fires to aid in our analysis. Four different aspects of these fires are currently being examined: 1) vegetative responses to prescribed and wildland fire, 2) invasive species response to wildland fires, 3) hydrophobic conditions associated with wildland fire, and 4) social implications surrounding fire. This study is underway in collaboration with the United States Forest Service, University of Wyoming, and Southern Rockies Fire Science Network. The immediate, post-fire results and implications of the project will be shared during the discussion. Our experience indicates

that incorporating incident management with real-time wildland fire modules to generate feedback about fire use and post-fire recovery is an advantage.

YOU CAN LIVE IN THE WILDLAND URBAN INTERFACE BY ADAPTING TO WILDFIRE. Ron Biggers*; Glenwood Springs Fire Department, Glenwood Springs, CO

In the West much of the developable land for homes is in the Wildland Urban Interface (WUI) where risk of fire impacts is much greater.
The following practices would improve life safety for fire fighters and residents and limit the loss of homes: thoughtful land use planning, careful selection of exterior home construction materials, strategic landscaping in subdivisions and mitigation of existing wildfire hazard fuels in and around the built environment.
This short talk will address these practices and illustrate how future WUI dwellers can give their home a greater chance of surviving a wildfire and at the same time make it safer for firefighters to protect their property.

Symposium:
Wild Horse and Burro Issues

THE ECOLOGIC, ECONOMIC AND POLICY CHALLENGES OF THE WILD HORSE AND BURRO ACT OF 1971. Redge Johnson*; Utah Governors Office, SLC, UT
The appropriate management level (AML) for wild horses is 27,000 animals, current population on the range exceeds 70,000. The 43,000 animals above objective are stressing the landscape and creating conflicts with other wildlife and domestic animals through degraded rangelands. Additionally, 46,000 horses and burros are housed in long term holding facilities at a cost of $48,000.00 per animal for its lifetime. When combined with the excess animals on the Rangte this is a potential 2.2 billion dollar expense. As Wild Horse and Burro populations increase on average 20 percent per year, this issue has potential for significant negative impacts on rangeland, wildlife, ecosystems, taxpayers and local economies. To assist policy makers and program managers this SRM symposium will address the ecological threshold of range, grazing habits equine and other species, potential conflicts with sensitive and endangered species, economic challenges to local economies and families and political realities of this challenging issue.

MANAGEMENT DECISIONS, ECOLOGICAL THRESHOLDS AND THE HEALTH OF RANGELAND ECOSYSTEMS. Tamzen K. Stringham*; University of Nevada, Reno, Reno, NV

Public land management agencies utilize Ecological Site Descriptions (ESDs) and their associated state-and-transition model (STM) for determining the ecological health or state of rangelands. ESDs synthesize information concerning soils, hydrology, ecology, and management into a user friendly document, whereas the STM identifies the various alternative vegetation states, describes the disturbances that cause ecological thresholds to be breached and the restoration activities needed to restore plant communities and rangeland function. Ecological thresholds associated with excessive and chronic herbivory typically occur slowly over many years and indicators of degradation may go unnoticed prior to a threshold event. STMs provide managers with an ecologically sound tool for multiple applications including determining current ecological state, designing monitoring or habitat restoration objectives and setting carrying capacity at landscape scales. ESDs and STMs in combination with vegetation monitoring can be utilized to determine the current condition of Herd Management Areas, identify impending and irreversible ecological thresholds and to set ecologically sound Appropriate Management Levels.

INFLUENCE OF EXOTIC HORSES ON LIMITING RESOURCE USE BY NATIVE WILDLIFE IN THE GREAT BASIN. Brock R. McMillan*[1], Lucas K. Hall[1], Robert N. Knight[2], Randy T. Larsen[1]; [1]Brigham Young University, Provo, UT, [2]US Army Dugway Proving Ground, Dugway, UT

Exotic wildlife can have negative direct and indirect impacts on communities of native wildlife. Exotic species may directly compete with native wildlife for resources or indirectly alter structure and quality of habitat for native species. These direct and indirect effects would be most apparent in areas of high community overlap or use where the potential for interspecific interactions is greatest. In arid regions, water is limiting and locations with water are likely areas of communal aggregation that may become flash points for interspecific interactions. Our objective was to determine if exotic horses negatively influenced the community of native wildlife. More specifically, we compared species richness and diversity of wildlife communities at water sources with and without feral horses (*Equus caballus*) in the Great Basin Desert, Utah. We predicted that exotic horses would negatively influence species richness and diversity of native communities that access limiting sources of water. We used infrared-triggered cameras to detect mammalian and avian species at 32 water sources. We obtained 67,458 photographs of mammals (comprised of 16 species) and 34,038 photographs of birds (comprised of 60 species). Species richness and diversity were greater—nearly double—at water sources where horses were absent than at water sources where horses were present. There were no differences among water sources in landscape juxtaposition or surrounding habitats beyond the very local scale suggesting the differences are likely due to the presence of feral horses. Water sources and the immediate surroundings that were used by horses were typically degraded and denuded of natural vegetation (due to trampling). Our results indicate that exotic horses may exclude native species from access to a limited

resource.

WILD NATIVE UNGULATE MANAGEMENT IN WESTERN NORTH AMERICA.

Jim Heffelfinger*; Arizona Game and Fish Department, Tucson, AZ

Wild native ungulates are some of the most economically and socially important wildlife in western North America. In a 2006 survey of outdoor activities, the U. S. Fish and Wildlife Service reported nearly 3 million people hunted in the 19 western states and millions more enjoy seeing these animals. In 2006 alone, hunters were afield for almost 50 million days and spent more than $7 billion in local communities across the West on lodging, food, fuel, and hunting-related equipment. Fluctuations of wild native ungulate populations during the past century have increased interest in their management, continued conservation, and the ecological integrity of their habitat. Monitoring wildlife populations is one of the most basic elements of wildlife management. Because conducting a census of an entire population is rarely feasible, sampling is required and rigorous methods are necessary to base management on a sound
foundation. Management of wild native herds of ungulates follows principles developed over decades of research and management experience. Populations are monitored in a consistent fashion and management actions are prescribed to achieve population objectives. Management decisions are annually monitored for effect and adjusted accordingly to maintain populations within the carrying capacity of the habitat and the social constraints of the public for whom wildlife are managed. The continued health and stability of wild native ungulate populations in North America will depend on appropriately managing their habitat needs on a multiple use landscape with a focus on regional collaboration, rigorous monitoring methods, data analysis and sharing, and the practical application of adaptive harvest management principles.

BREAKING THE CYCLE: CAN COOPERATION AND COMPROMISE HELP HORSES AND OTHERS WHILE IMPROVING RANGELAND HEALTH?

Holly E. Hazard*; The Humane Society of the United States, Washington, DC

The Bureau of Land Management has removed an astounding 240,000 wild horses and burros from federal lands in the past 45 years. During this time, stakeholders across the spectrum have registered dissatisfaction with their actions. The government has been sued for removing animals, contracepting or gelding and for just leaving them be. Several years ago, the government initiated a controversial and aggressive removal program that brought the herds close to Appropriate Management Levels (AML) but also seeded the agency's current precarious financial predicament. The agency now cares for so many horses in long-term holding, it is largely paralyzed from managing the range. Ranchers, environmentalists, horse advocates and even the agency all agree on one thing—the program isn't working.

Shifting strategy from the short-term satisfaction of removals to more sophisticated and

successful programs requires trust, patience, empathy and collaboration from all stakeholders. It is, however, the only path forward to successful manage this iconic, but challenging, animal.

WILD HORSES AND BURROS ACT (1971); PUBLIC LAND MULTIPLE USE; AND MANAGEMENT CHALLENGES. Dean O. Bolstad*; Bureau of Land Management, Washington, DC

The Wild Free-roaming Horses and Burros Act (1971) as amended requires the protection, management, and control of wild free- roaming horses and burros (WH&B) on public lands managed by the Forest Service and the Bureau of Land Management.   The Act requires these animals to be managed as components of the public lands and limits their distribution to areas they occupied in 1971. Populations are to be managed in manner designed to achieve and maintain a thriving natural ecological balance and in keeping with the multiple-use management concept for the public lands. Once a determination that overpopulation exists and excess animals are present, agencies are to remove them from the range to achieve appropriate management levels. Animals that have been removed from the range are to be made available for adoption and private maintenance and care. The Act has provisions for the destruction of animals for which no adoption demand exists and to sell without limitation those animals older than ten years or that have been passed over for adoption three times. Annual legislation has prohibited the Bureau of Land Management from implementing these provisions since 2010. Land managers have difficulty controlling herd growth. Currently, on-range populations significantly exceed target management numbers.

Symposium:
Watershed Restoration – Working Together Across Ownership Boundaries to Design, Develop, and Implement Conservation Actions

UTAH'S WATERSHED RESTORATION INITIATIVE – RESTORING WATERSHEDS AT A LANDSCAPE SCALE. Tyler W. Thompson*; Utah Division of Wildlife Resources, Salt Lake City, UT

Utah's Watershed Restoration Initiative is a partnership based program in Utah to improve high priority watersheds throughout the state. WRI is sponsored by the Utah Partners for Conservation and Development and is in its 11th year. The Watershed Program focuses on three ecosystem values: 1) wildlife and biological diversity, 2) water quality and yield, and 3) opportunities for sustainable uses of natural resources. WRI is a bottom-up initiative where project planning, review, and ranking occur at a local level. Five regional teams elect their own leaders, establish focus areas, review, score and rank project proposals using a comprehensive project prioritization score sheet, and assist their members in implementing projects.

WRI through its partners provides a number of project services including: funding, assistance with project planning and implementation, cultural resource and project contracting and accounting, seed purchasing, storage, mixing and delivery, free use of restoration equipment, project monitoring and reporting, on the ground project management, and an on-line project tracking database (wri.utah.gov) and information website (watershed.utah.gov). The locally-led teams provide a means to work on a landscape scale across ownership boundaries.

Since 2006, WRI partners have completed nearly 1,500 projects and are approaching 1.5 million acres treated. As of 2016, nearly 500 agencies, organizations and individuals have contributed to WRI projects by providing funding and/or in-kind assistance. Projects can generally be categorized into two types, restoration projects to improve the health of watersheds and rehabilitation projects following wild fire to re-establish the structure and function of watersheds. We are often asked about how WRI has been able to achieve such success in such a short time. This presentation will highlight the history, organization, management and keys to the success of WRI in Utah.

UTAH'S GREAT BASIN RESEARCH CENTER: SEED, EQUIPMENT, RESEARCH, AND MONITORING FOR THE WATERSHED RESTORATION INITIATIVE. Danny Summers*, Kevin Gunnell; Utah Division of Wildlife Resources, Ephraim, UT

The Utah Watershed Restoration Initiative (WRI) is a partnership-driven effort to conserve, restore and manage ecosystems in priority areas across the state of Utah. The Utah Division of Wildlife Resources (UDWR), Great Basin Research Center and Seed Warehouse (GBRC), in Ephraim, Utah, is a key logistical cog in accomplishing hundreds of proactive restoration projects across the state each year since the initiative started in 2005. The UDWR seed warehouse acquires hundreds of thousands of pounds of seed for restoration and rehabilitation projects each year through pooled funds of the WRI. The seed warehouse has also been extremely valuable to the State of Utah, BLM and Forest Service in extreme fire seasons by having the ability to quickly and efficiently acquire, store, mix, and distribute seed for fires across the state. The GBRC also provides specialized equipment for seeding and seed bed preparation for all partners in the WRI. The GBRC is also an important center for the development of native seed and restoration techniques. Also located at the GBRC is the Range Trend Project which has been monitoring the trends and conditions of important wildlife ranges since the 1980's. Since the inception of the WRI, the Range Trend Project has been monitoring selected restoration projects with both pre- and post-treatment monitoring. The GBRC plays a behind the scene role, but is vitally important to the success of the WRI.

NEPA IS NOT A FOUR-LETTER WORD! Vicki J. Tyler*; Bureau of Land Management, Cedar City, UT

Just mention the National Environmental Policy Act and most people will experience varying degrees of aversion. However, landscape-level NEPA continues to be key to achieving on-the-ground project success for the BLM Color Country District, through Utah's Watershed Restoration Initiative. As a matter of fact, all federal land management agencies now have national policy that encourages collaboration and planning at a watershed/landscape level. Instead of spending time working for NEPA, let NEPA work for you! Demystifying the process is the first step in getting out of the office and into the field and in doing more with less!

UTAH'S WATERSHED RESTORATION INITIATIVE AND CULTURAL RESOURCE COMPLIANCE. Monson W. Shaver*; Department of Natural Resources, Salt Lake City, UT

The Utah Watershed Restoration Initiative brings together federal, state and private entities in an effort to improve watersheds across the State of Utah. Federal and state statutes require agencies to evaluate the effects of these proposed projects on historic properties (i.e. buildings, archaeological sites) through a process known as the Section 106 Review. Completing this process requires coordination between federal and state cultural resource specialists. One of the strengths of watershed restoration projects is that they disregard property boundaries, utilizing resources from multiple agencies across various property ownerships. However, this then necessitates multi-agency cooperation in addressing cultural resource protection. In cases of multi-agency projects, the largest land holding federal agency takes the lead in project review and consultation with the State Historic Preservation Office (SHPO). Unless designated by a federal agency, state agencies cannot consult with SHPO for a federal entity concerning historic properties. Cooperation is required with project managers and cultural resource specialist throughout the yearlong process, from making a determination of requiring cultural resource inventories, cost estimates, contracting for cultural resources inventory, report and site review and final SHPO consultation concurring on site eligibility and project effect determinations. Estimating cultural resource inventory costs requires set contract prices per acre, which also allows for quick deployment of contract inventories. Project managers are required to avoid cultural resource sites during project implementation when sites are determined through the 106 process as eligible to the National Register of Historic Places. The cooperation required by the Watershed Restoration Initiative results in the production of site documentation, a report and a single agency SHPO consultation saving time and monies across all agencies.

BUREAU OF LAND MANAGEMENT – LANDSCAPE APPROACH INITIATIVES. Thomas J. Adamson*; Bureau of Land Management, Salt Lake City, UT

The Bureau of Land Management (BLM) recognizes that the public lands are facing increasingly complex and widespread environmental challenges that transcend traditional management boundaries. These challenges include managing wildfire, controlling weeds

and insect outbreaks, providing for energy development and urban growth, and addressing pervasive impacts from the effects of climate change.

The BLM's landscape approach builds on land management concepts and experiences that have been evolving for nearly three decades. BLM managers recognize that western forests and rangelands can no longer be managed effectively by local offices alone, or through traditional management practices. Scientists, land managers, and stakeholders have been working since then to understand these wide-ranging impacts, develop shared strategies, and implement collaborative management efforts. These collective experiences and partnerships make up the Utah Watershed Restoration Initiative (UWRI). Utah BLM has entered into a cooperative agreement with the State of Utah's Division of Wildlife Resources using Legislative Authority (Wyden Amendment Act 16 U.S.C. 1011). This authority allows for watershed restoration and enhancement treatments that span multiple jurisdictional boundaries. Through this agreement the BLM is able to carry out numerous landscape initiatives that benefit wildlife, watershed health and resistance/resilience to multiple change agents.

COOPERATIVE CONSERVATION - A WATERSHED APPROACH TO GET CONSERVATION ON THE GROUND. Elise Boeke*; USDA-Natural Resources Conservation Service, Salt Lake City, UT

At NRCS, our mission is to help people help the land. We do that through cooperative conservation and a watershed approach. Our primary customers are farmers and ranchers and other private entities involved in agriculture. But here in Utah, many of our farmers and ranchers are also operating on other, non-private lands. We can't be successful in achieving our mission without effective partnerships which allow us to work across boundaries. NRCS is in a unique position to facilitate relationships regardless of boundaries and provide technical expertise in designing and implementing conservation actions. Today you will learn about how NRCS identifies and assess resource concerns, focuses our efforts, and leverages our finances to achieve healthy working lands regardless of boundaries. I'll show you some examples of successful partnerships and some of the opportunities we have available to work collaboratively with partners to get conservation on the ground.

POST FIRE REHABILITATION AND THE UTAH WATERSHED RESTORATION INITIATIVE THEN AND NOW. Paul N. Briggs*; USDI Bureau of Land Management, Cedar City, UT

Successful fire rehabilitation efforts are a critical part of management at a landscape scale. In areas with large fires and mixed land ownerships, an effective partnership with an "all hands all lands" approach is required.

Since the inception of the Utah Watershed Restoration Initiative (WRI), coordinating and accomplishing successful revegetation and long term management of these areas has greatly improved. The many treatment methods and technologies available can be used

to achieve multiple use objectives on a variety of sites and across multiple ownerships. This presentation will illustrate processes and results of fire rehabilitation efforts pre and post WRI.   This unique partnership is why Utah is at the forefront in landscape-level restoration and why the pre-WRI way of doing business is a thing of the past.

Paul Briggs graduated from Utah State University in Range Science. He has spent the last 13 years as the Fuels Program Manager for the BLM's Color Country District and is currently the acting Cedar City Field Manager.

CUTTHROAT TROUT AND COWS BENEFIT FROM PROJECTS FUNDED BY UTAH'S WATERSHED RESTORATION INITIATIVE. Jim DeRito*[1], Paul Burnett[2]; [1]Trout Unlimited, Providence, UT, [2]Trout Unlimited, Ogden, UT

Trout Unlimited works with a variety of partners to develop projects that benefit rangelands as well as streams and fish across public and private lands. The WRI has been a key funding source and process with which to develop these projects in Utah. We highlight three examples in Northern Utah where these mutual benefits across ownership boundaries have been achieved with the WRI. The first project occurred in the National Forest headwaters of the Bear River in the Uinta Mountains. An irrigation diversion on forest was completely rebuilt to improve the rancher's water operation and maintenance to deliver water to private ground. In return, a fish screen was installed in the irrigation canal to prevent fish loss to the canal. In the Weber River watershed, WRI played an important role in bringing landowners together to reconnect habitat for cutthroat trout by removing a failed culvert and reconstructing and stabilizing the stream. This has led to greater collaboration among landowners to solve the watershed scale issues and develop additional projects to improve irrigation and rangeland. The third project involved rebuilding numerous irrigation diversions and replacing undersized culverts to improve fish passage on over twenty miles of stream on Bureau of Land Management and private lands. This work facilitated the reintroduction of cutthroat trout across these lands. In all three cases, irrigation water delivery and conditions for cutthroat trout have been greatly improved on rangelands across ownership boundaries.

MONROE MOUNTAIN ASPEN ECOSYSTEMS RESTORATION PROJECT – CHALLENGES AND BENEFITS OF COLLABORATION AND LANDSCAPE SCALE ENVIRONMENTAL ANALYSIS. Jason E. Kling*; USDA Forest Service, Richfield, UT

The Richfield Ranger District (District) of the Fishlake National Forest has been working collaboratively with the Monroe Mountain Working Group (MMWG) (21 stakeholders) to develop strategies to improve aspen ecosystems on Monroe Mountain; part of which includes reintroducing disturbance (prescribed fire and mechanical thinning) and making adjustments to livestock and wildlife management to reduce aspen browse pressures. Reintroducing disturbance at a landscape scale (approximately 42,000 acres)

and making adjustments to livestock and wildlife management to improve and maintain aspen ecosystems while also minimizing impacts to private property and other uses on Monroe Mountain has been a challenging task. The Monroe Mountain area, located in Central Utah, encompasses approximately 176,000 acres of National Forest lands and approximately 12,000 acres of private inholdings. Dominant vegetation includes aspen and conifer in the higher elevations and sagebrush and pinyon/juniper in the lower elevations. Monroe Mountain provides elk and mule deer habitat with associated hunting opportunities, multiple allotments for livestock grazing, boreal toad and Bonneville cutthroat trout habitat, Northern goshawk and Flammulated owl habitat, Inventoried Roadless Areas, and much more. In December 2015, the District released a Final Environmental Impact Statement and Final Record of Decision (ROD) that outlines a 10 year plan to improve aspen ecosystems at a landscape scale on Monroe Mountain. The Utah Department of Wildlife Resources has been a Cooperating Agency. Project implementation started in spring 2016. This collaborative approach has been enlightening and a success on the Fishlake National Forest, Richfield Ranger District.

IN SEARCH OF THE SMOKING GUN: LINKING THE SCIENCE TO MANAGEMENT AND POLICY. Terry A. Messmer*[1], Dave K. Dahlgren[1], S. Nicole Frey[2], Lorien Belton[1], Randy Larsen[3]; [1]Utah State University, Logan, UT, [2]Utah State University, Cedar City, UT, [3]Brigham Young University, Provo, UT

In March 2010, the US Fish and Wildlife Service (USFWS) designated the greater sage-grouse (*Centrocercus. urophasianus*) as a candidate species for protection under the Endangered Species Act. Because sage-grouse are landscape species that inhabit lands owned by multiple jurisdictions, the management of these areas to maintain connectivity between populations will be paramount to their conservation. Within Utah, Governor Gary H. Herbert chartered a Task Force to develop a statewide plan for the conservation of sage-grouse and provide for the continued economic health of the state. The Conservation of Greater Sage-grouse in Utah (Plan) was published in 2013. The Plan was an alternative hypothesis to an ESA listing. It was developed using information collected over two decades of research sponsored by a community-based conservation (CBCP) adaptive resources management local working group (LWG) process throughout Utah. This process has enhanced communications and collaboration among private stakeholders, local, regional and state governments, and state and federal management agencies and mitigated statewide conservation threats to sage-grouse and other sagebrush (*Artemisia* spp.) obligate species. Because of this effort, the state of Utah possessed unparalleled knowledge about the factors essential to the species conservation. When the efforts were aggregated into a statewide plan for sage-grouse, the collective result provided an organized approach for addressing the factors used by the USFWS to measure the success of conservation actions. success of each LWG plan rests on the CBCP's ability to work with partners to fund the research needed to obtain better information about the effects of specific management practices on sage-grouse. The CBCP process combined local knowledge into an integrated extension and research program that allowed LWG members to learn together how best to manage the landscape

while they were actively managing it. This research has linked science to policy and management to guide Utah sage-grouse conservation efforts.

Oral Technical Session:
Vegetation Management and Restoration II

HERBACEOUS YIELD RESPONSE TO VARIOUS WESTERN JUNIPER TREATMENTS. Jonathan Bates*[1], Kirk W. Davies[2], Tony Svejcar[3]; [1]USDA-ARS, Burns, OR, [2]USDA - Agricultural Research Service, Burns, OR, [3]USDA-ARS, Burns, OR

Western juniper has expanded and infilled many plant communities of the semi-arid Pacific Northwest the past 130 to 150 years. The increase in juniper reduces herbaceous forage and shrub browse for livestock and big-game. We measured herbaceous production across a range of plant communities following cutting or prescribed fire treatments in Phase 1 (early), Phase 2 (mid-succession) and Phase 3 (late-succession) western juniper woodlands. Results indicate that fire (2 to 3-fold increase) was more effective than cutting (no change to 1.5-fold increase) at increasing herbage production in woodlands that are in early (Phase 1) and mid (Phase 2) successional stages. In late successional stands (Phase 3) cutting and prescribed fire resulted in similar increases in herbage production. The amount of increase in Phase 3 woodlands varied considerably (2 to 10-fold increases) depending on site potential. Composition of herbaceosus response is variable and tends to be fairly predictable following cutting treatments (all woodland phases) and following fire in Phase 1 and 2 woodlands.

BROWSING IMPACTS RESPROUTING SHRUB PHYSIOLOGY IN A WOODY ENCROACHED GRASSLAND. Rory C. OConnor*[1], Mira Ensley-Field[2], Jeff Taylor[1], Jesse Nippert[1]; [1]Kansas State University, Manhattan, KS, [2]Macalester College, St. Paul, MN

Woody encroachment into grasslands, savannas, and steppes have become a management and conservation concern because of woody plant's ability to change ecosystems through decreases in biodiversity, alterations in water and nutrient cycles as well as decreases in forage production and quality. In grasslands, woody encroachment can be categorized in to two groups: non-resprouting species that can be killed with fire and resprouting species that cannot be killed with fire. Resprouting species require additional active management strategies to remove them from encroached grasslands. In this study, we investigated the physiological effects of continuous browsing on a resprouting woody species. In 2015, at the Konza Prairie LTER, 40 discrete *Cornus drummondii* shrubs were selected at two woody encroached watersheds. During the growing seasons 20 shrubs received a continuous simulated browsing treatment of 50% removal of new aboveground meristematic growth. Each month we sampled leaf gas exchange, leaf δ13C, leaf temperature and LAI. The simulated browsing treatment continued through 2016.

After two years of continuous simulated browsing we found that browsing does not change the rate of photosynthesis but it does change the stomatal conductance and transpiration rates. Midday stomatal conductance and transpiration rates were higher compared to unbrowsed shrubs. Additionally, we found that browsed shrubs had a 0.5‰ – 1.5‰ lower δ13C value compared to the unbrowsed shrubs, complementing the observed increase in stomatal conductance. Leaf temperatures did not vary significantly between browsed and unbrowsed shrubs but did vary throughout the diel period in the growing season. With no difference in leaf temperature between browsed and unbrowsed shrubs and the increased transpiration rates in browsed shrubs, we hypothesize that browsed shrubs are lowering their leaf temperatures through increased water use to avoid photorespiration. Browsing alone is not enough to decrease woody encroachment but coupled with fire it could provide a realistic management strategy.

EVALUATING ECOSYSTEM SERVICES AND TRADE-OFFS IN THE CONTEXT OF BRUSH MANAGEMENT. Adam T. Naito*[1], Steven Archer[1], Greg A. Barron-Gafford[1], Philip Heilman[2], Katharine I. Predick[1], Heather L. Throop[3]; [1]University of Arizona, Tucson, AZ, [2]USDA Agricultural Research Service, Tucson, AZ, [3]Arizona State University, Tempe, AZ

Brush management activities have traditionally been undertaken to reduce woody cover in an effort to improve forage production on managed rangelands where undesirable woody plants have proliferated. Yet, economic analyses suggest that this sole focus is often financially unjustified. Quantification of the long-term effects on other ecosystem services (ESs) (biodiversity, carbon sequestration, water quality, soil nutrients) and associated trade-offs will enhance our ability to objectively evaluate the ecological impacts of woody encroachment and the cost-benefit of brush management as a conservation practice. Long-term, watershed-scale assessments of ESs, however, are lacking. In an effort to better position us to make these assessments, we are quantifying the effects of brush management on a suite of ESs on four instrumented watersheds on a velvet mesquite (Prosopis velutina)-invaded desert grassland in southeastern Arizona. Pre-treatment herbaceous diversity and aboveground (herbaceous and woody live and litter) and belowground (soil organic C and roots to 20 cm) carbon pools were quantified in 2015 and early 2016 on all watersheds prior to initiating an aerial herbicide brush management treatment in June 2016 on two of the watersheds. These variables were subsequently re-quantified in September 2016. Early results indicate that the frequency of occurrence of both native and nonnative grasses has increased on the treated watersheds relative to controls. In addition, there was a 100% increase in herbaceous biomass. Data will be collected for at least three additional years and will be supplemented with unmanned aerial vehicle imagery. Extended monitoring will be conducted under the auspices of the USDA-ARS Long Term Agricultural Research program. Collectively, these data will be used to parameterize ecosystem and hydrological simulation models to predict long-term ecosystem responses and provide for more effective and comprehensive cost-benefit analyses of brush management.

DEVELOPING STATE-AND-TRANSITION MODELS FOR ASPEN DOMINATED SITES IN WESTERN COLORADO. Christopher P. Dickey*[1], Maria Fernandez-Gimenez[2], Paul Meiman[2], Retta Bruegger[3]; [1]MS Student at Colorado State University, Fort Collins, Fort Collins, CO, [2]Colorado State University, Fort Collins, CO, [3]Colorado State Extension, Grand Junction, CO

In Colorado, quaking aspen (*Populus tremuloides Michx.*) is widely regarded as a species of great ecological, economic, and aesthetic importance. In response to needs expressed by landowners and land managers, we partnered with those groups and developed a state-and-transition model (STM) specific to aspen dominated ecosystems in western Colorado. We surveyed soils, vegetation and presence and intensity of browsing on 68 plots across 4 different study sites, including adjacent plots on similar soils with and without aspen, and aspen sites with and without burns and clear cuts. To identify potential plant communities and states, we performed agglomerative hierarchical cluster analysis and selected clusters using indicator species analysis. We used Multi-response Permutation Procedure (MRPP) to determine whether or not potential communities differed significantly by species composition. We then determined whether or not these communities are distinct states by using MRPP to test for differences in functional characteristics. Finally, we used Nonmetric Multidimensioanal Scaling (NMDS) to relate species composition to static abiotic drivers and dynamic management and disturbance variables (fire, browsing, and clearcutting). We will present our draft models and describe how the results of our analyses were used to create locally relevant STMs for the sites in which we worked.

EVALUATION OF THE EFFECTS OF WILDFIRE AND SHRUB REDUCTION PROJECTS ON SAGEBRUSH RANGELANDS ACROSS UTAH. Kari E. Veblen*[1], Corinna Riginos[2], Kevin Gunnell[3], Thomas A. Monaco[4]; [1]Utah State University, Logan, UT, [2]U. Wyoming, Laramie, WY, [3]Utah Division of Wildlife Resources, Salt Lake City, UT, [4]USDA ARS, Logan, UT

Treatments to reduce shrub cover are commonly implemented on the assumption that they will increase herbaceous perennial production. However, these treatments can have variable effects on shrub cover, herbaceous perennials, and non-target herbaceous annuals, and the factors mediating this variability are not well understood. In the sagebrush rangelands of the Intermountain West, the need to understand the outcomes of shrub reduction treatments has gained importance as management focuses on the needs of sensitive species such as sage-grouse. We used long-term data from Utah's Watershed Restoration Initiative (WRI) project (initiated in 2003) to assess short-term (1-5 years post-treatment) and long-term (6-12 years post-treatment) responses of sagebrush plant communities to five shrub reduction treatments at sites across Utah (n=96 total): wildfire with and without post-fire seeding, pipe harrow with one or two passes, and aerator. We used moderator analyses to investigate the effects of treatments on changes in cover of

sagebrush (*Artemisia tridentata*), grasses, and forbs within each of three sagebrush sub-species communities. Shrub reduction treatments only increased perennial grasses substantially in *A. tridentata* ssp. *wyomingensis* sites (all treatments) and in ssp. *vaseyana* sites that were seeded after fire. Perennial forb cover increased in all treatments (except aerator) in the short-term, but these effects only persisted in the long-term in ssp. *Wyomingensis* sites. Annual grasses (largely cheatgrass, *Bromus tectorum*) increased in all treatments in ssp. *vaseyana* sites but stayed constant or decreased (especially in sites seeded after fire) in ssp. *Wyomingensis* and ssp. *tridentata* sites. In contrast to these shrub community-dependent effects of treatment, site factors (elevation, slope, and precipitation) rarely had significant effects on cover responses to treatments. Although these results provide some evidence that perennial cover increases as a result of shrub reduction, they also illustrate that this outcome depends on sagebrush community and does not persist in the long-term.

VARIATION IN SAGEBRUSH COMMUNITIES HISTORICALLY SEEDED WITH CRESTED WHEATGRASS IN THE EASTERN GREAT BASIN. Justin R. Williams*[1], Lesley R. Morris[2], Kevin Gunnell[3], Jamin Johanson[4], Thomas A. Monaco[5]; [1]USDA-Agricultural Research Service, Logan, UT, [2]Oregon State University, La Grande, OR, [3]Utah Division of Wildlife Resources, Ephraim, UT, [4]USDA-NRCS, Monroe, UT, [5]USDA ARS, Logan, UT

Although crested wheatgrass (*Agropyron cristatum* [L.] Gaertn. & *A. desertorum* [Fisch. ex Link] Schult.) has been one of the most commonly seeded exotic species in the western United States, long-term successional trajectories of seeded sites are poorly characterized, especially for big sagebrush (*Artemisia tridentata* Nutt.) ecosystems in the Great Basin, USA. Interpreting successional trajectories is particularly difficult because many seeded sites were actively managed with subsequent treatments to kill sagebrush and sustain high forage productivity of crested wheatgrass plants. In addition, inherent differences in climate, topography, soils, and disturbance regimes may lead to variable vegetation structure and species composition among seeded sites. To clarify variation in successional trajectories, we measured vegetation composition, plant species diversity, ground cover, and soil properties in 38, historical crested wheatgrass seedings distributed across 146 sampling sites that lacked subsequent sagebrush treatments. The multivariate dataset was analyzed using principal components analysis (PCA) to identify "defining factors" that best explained variation among sites. Variation was primarily attributed to an inverse relationship between crested wheatgrass and sagebrush abundance ($R2 = 0.69$; $P < 0.0001$) and their affinity for either silty or sandy soil textures, respectively, as well as a negative association between crested wheatgrass abundance and species diversity ($R2 = 0.67$; $P < 0.0001$). These results do not support the assumption that crested wheatgrass seedings uniformly remain in vegetation states with low diversity and poor sagebrush re-establishment over the long term (i.e., 43-63 years). We suggest that a broader interpretation of plant community dynamics is needed while avoiding generalizations of how historically seeded Wyoming big sagebrush sites will respond over time.

WEATHER AND CLIMATE TOOLS FOR PLANNING AND ASSESSMENT ON RANGELANDS. Corey Moffet*[1], Stuart Hardegree[2], Mark Brunson[3], John Abatzoglou[4]; [1]USDA-ARS, Woodward, OK, [2]usda ars, fort collins, CO, [3]Utah State University, Logan, UT, [4]University of Idaho, Moscow, ID

A primary abiotic driver of many rangeland processes is the weather. When assessing the efficacy of a treatment it is important that these assessments be made within the context of the weather conditions that occurred during the treatment assessment. For example, rangeland-seeding practices, especially in the Intermountain West of the United States, are typically implemented in a single planting season for the purposes of Emergency Stabilization and Rehabilitation (ESR) after a wildfire. This situation links the restoration activity and rehabilitation success to the probability that this single year will provide sufficiently favorable microclimatic conditions for desirable plant establishment. Analysis of climatic data may suggest that by, for example, shifting the planned planting date, managers could alter the probability of achieving a successful restoration. Field research studies in rangeland restoration are also typically of limited duration, with few seeding events, and published results may not represent the full spectrum of climatic conditions likely to occur at a given site. Location-specific and temporal weather-analysis may enhance the interpretation of historical results, support expanded inferences from short-term field studies, and facilitate meta-analysis of diverse field studies for rangeland treatments, such as restoration. We describe access and use of new databases and tools that can be used for this purpose, and suggest some standard graphs and weather metrics to establish a longer-term perspective for the interpretation of rangeland restoration field results.

ARMY CUTWORMS (*EUXOA AUXILIARIS*) CONSUME WINTER ANNUAL PLANTS AND SHRUB FOLIAGE. Cindy Salo*; Sage Ecosystem Science, Boise, ID

Large numbers of army cutworms (*Euxoa auxiliaris*) consumed above-ground portions of winter annuals and the foliage of sagebrush and chenopod shrubs in northern Owyhee County, Idaho in early 2014. This insect outbreak appears to have been the result of 1) numerous adult moths returning to the area the previous fall to lay eggs, followed by 2) a large rainstorm to germinate winter annuals, followed by 3) a warm, dry winter to allow high survival of larvae. I monitored four sites affected by army cutworms in northern Owyhee County from March 2014 to June 2015. I recorded qualitative and photographic data, including video, of army cutworm herbivory and the subsequent recovery of vegetation. In this talk, I'll tell the story of how, over a dozen years, I learned about the population dynamics of these nocturnal larvae and their effects on sagebrush steppe vegetation. I'll also describe the life history of the species, which, as adult miller moths, are an important food for grizzly bears in the Greater Yellowstone Ecosystem.

BEYOND HONEY MESQUITE: BROADENING THE USES OF SENDERO®
HERBICIDE (AMINOPYRALID + CLOPYRALID). Daniel C. Cummings*[1], Charles R.
Hart[2], Megan Clayton[3], James Jackson[4], Robert K. Lyons[5]; [1]Dow AgroSciences,
Bonham, TX, [2]Dow AgroSciences LLC, Stephenville, TX, [3]Texas A&M AgriLife
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Extension, Stephenville, TX, [5]Texas A&M AgriLife Research and Extension, Uvalde,
TX

Sendero® herbicide (aminopyralid + clopyralid) was introduced to the southwest USA in
2012 as The New Standard For Mesquite Control™. In south Texas, mesquite (*Prosopis
glandulosa*) is often a component of a mixed brush complex of hard to control woody
species. In other parts of Texas, honeylocust (*Gleditsia triacanthos*) is a common
invader of rangelands and pastures, displacing native vegetation and decreasing desirable
forage production. In 2013 and 2014 a series of experiments (n=4) were conducted in
south Texas to investigate the tank mixes of Sendero plus Tordon® 22K or Remedy®
Ultra in aerial applications. Evaluations were made to determine apparent mortality of
species typically found in the south Texas mixed brush complex. Concurrently, a series
of experiments (n=4) were conducted in north central Texas to evaluate Sendero and
other herbicides for control of honeylocust with aerial applications on
rangelands. Mortality data from 1 and 2 years after treatment indicate that tank mixes of
Sendero with Tordon or Remedy Ultra show equal to or better control of all brush species
(including catclaw acacia, blackbrush acacia, granjeno, guajillo, huisache, huisachillo,
lotebush, and mesquite) compared to Sendero alone. Sendero tank mixes are equivalent
or better to current tank mix recommendations for mesquite and south Texas mixed
brush. In the north Texas aerial broadcast herbicide trials, Sendero at 28 fl oz/ac resulted
in an average of 80% apparent mortality of honeylocust and provided selectivity of
control, leaving most other hardwoods unharmed. Aerial applications of Sendero resulted
in significantly better control than current industry standards for chemical
application. This research further demonstrates the utility of Sendero herbicide in
southwestern US brush management.

DURATION OF ACCESS MAT APPLICATION INFLUENCES MIXEDGRASS
PRAIRIE PLANT COMMUNITY COVER AND COMPOSITION. Kassia S. James*,
Edward Bork, Cameron N. Carlyle, Karen A. Thompson; University of Alberta,
Edmonton, AB

Wooden access mats (e.g.. temporary roads) are a mitigation technique thought to limit
traffic impacts on soils and vegetation during industrial activities in grasslands. Mats
redistribute weight from vehicle traffic but also prevent photosynthesis by blocking
sunlight and reducing gas exchange. Here we assess the effect of timing and duration of
mat placement and compare these to un-matted plots, both with traffic treatment, and
non-treated controls. Mats were placed onto grassland study sites on April 30 for 6, 12, or
24 weeks, and on July 22, 2015 for 6 or 12 weeks. Traffic was simulated by driving a 28
ton loader over matted and un-matted plot pairs to simulate construction activity. Plant
cover and biomass were measured in August 2016. Preliminary findings indicate that

longer durations of mat placement caused larger shifts in community composition towards weedy species and a reduction in perennial native grass cover. Total biomass increased with longer durations of mat placement due to an increase in weedy species, which over compensated for a decrease in perennial grasses. Mat placement on actively growing vegetation (July) resulted in greater litter accumulation and general increases in biomass. Short duration placement prior to active plant green up resulted in the least negative effects on perennial grass cover. While further recovery of plant communities will be monitored to fully assess their resistance to disturbance regimes, our preliminary results suggest short-term mat placement (≤ 12 weeks) may be compatible with maintaining mixedgrass prairie.

GERMINATION CHARACTERISTICS OF 16 GRASSES . Obed Gutierrez[1], Alicia Melgoza-Castillo*[2], Carlos Morales[1], Federico Villarreal[1]; [1]Universidad Autónoma de Chihuahua, Chihuahua, Mexico, [2]Universidad Autonoma de Chihuahua, Chihuahua, Mexico

The germination characteristics are key parameters to elucidate how plants respond to environmental global changes, especially to the global climate change. Certain plant traits may determine the dynamics of vegetation as well as which species may become dominant. As a part of a long term project on the adaptation of plants to the climate change, the aim of this work was to compare germination velocity and seedling root:shoot ratio (R:S) on 16 grass species. Six exotic grass species and 10 natives were selected. Seed was collected from different ecosystems during 2014-2015. A total of 30 seeds were placed in a Petri dish, watered and placed into a germinator at 28±2 °C. Four replications per species were set. Germination seeds were counted every day and they were then discarded to facilitate further counting. In addition, root and shoot length were measured on seedlings of 7 days of age. There were significant differences on the germination velocity and R:S among (P<0.05) the species evaluated. *Leptochloa dubia, Bouteloua curtipendula* and *Eragrostis curvula* presented high germination velocities with values of 9.06, 6.23, and 6.35, respectively; compared to values of 0.31 for *E. lehmanniana*, 0.55 for *E. echinocloidea*, and 0.68 for *B. eriopoda*. High proportions of R:S were observed on *Muhlenbergia rigida* with 4.10 and *Melinis repens* with 2.73; compared to values of 0.55 for *E. echinocloidea.* A clear pattern was not observed for native and exotic species; however, these results, together with future trails, will be taken into account to determine which species may be more effective to get established under the conditions of the scenarios predicted for the global climate change.

Oral Technical Session:
Wildlife Habitat and Management

CANDIDATE CONSERVATION AGREEMENT WITH ASSURANCES - PROACTIVE SOLUTIONS FOR LANDOWNERS AND ENDANGERED SPECIES

ACT (ESA) CANDIDATE SPECIES. Leanne L. Correll*[1], Derek Scasta[2]; [1]University of Wyoming, Saratoga, WY, [2]University of Wyoming, Laramie, WY

Interest in management of western rangelands by a diverse set of stakeholder groups is greater than ever before. Socially, stakeholders are demanding scientific research for "science-based" management solutions. The need for "social" science and collaborative efforts to develop solutions for both sustainable agriculture and sustainable wildlife habitats is evident in the recent proposal for listing of the greater sage-grouse under the Endangered Species Act (ESA). The U.S. Fish and Wildlife Service's Candidate Conservation Agreement with Assurances (CCAA) is the only proactive, voluntary tool available for private landowners to obtain assurances to not be required to do more on private land if a candidate species was listed under the ESA. This conservation tool is available but not widely known. The Greater-Sage Grouse Umbrella Candidate Conservation Agreement with Assurances for Wyoming Ranch Management (SG-CCAA) is a success story of the proactive and voluntary CCAA tool. There have been eight separate petitions to list all or part of the greater sage-grouse range with the most recent 'non-warranted' listing determination from the U.S. Fish and Wildlife Service occurring in September 2015. Sage-grouse are considered an umbrella species in sagebrush habitats because conserving their populations and habitats benefits some 350 other species residing in the sagebrush ecosystem such as songbirds, small mammals, and ungulates. Sage-grouse are an indicator of healthy, functioning sagebrush steppe ecosystems. To increase the likelihood of private landowner's success with a voluntary SG-CCAA various outreach tools were developed. An Extension publication: Landowner Guide to Sage-Grouse Conservation in Wyoming was developed, two educational video series produced, and a Wyoming Extension Sage-Grouse website was created for use by private landowners and managers. The tools developed will expand opportunities for sage-grouse conservation success in Wyoming and the west.

ADAPTIVE USE OF NONLETHAL STRATEGIES FOR MINIMIZING WOLF-SHEEP CONFLICT IN IDAHO. Suzanne Stone*; Defenders of Wildlife, Boise, ID

Worldwide, native predators are killed to protect livestock, an action that can undermine wildlife conservation efforts and create conflicts between various stakeholders. An ongoing example is occurring in the western United States where wolves were eradicated by the 1930s but are again present in parts of their historic range. While livestock losses to wolves represent a small fraction of overall livestock mortality, the response to these depredations has resulted in widespread conflicts including significant lethal wolf control efforts to reduce impacts on livestock producers, especially those with large-scale grazing operations on public lands. A variety of nonlethal methods has proven effective in reducing livestock losses to wolves in small-scale operations but in large-scale, open range grazing operations nonlethal management strategies are often presumed ineffective or infeasible. To demonstrate that nonlethal techniques can be effective at large scales, we report a 7-year case study where we strategically applied nonlethal predator deterrents and adaptive animal husbandry techniques to protect sheep and wolves on public grazing lands in Idaho. We collected data on sheep depredation mortalities in the protected

demonstration study area and compared these data to an adjacent wolf occupied area where sheep were grazed without the added nonlethal protection measures. Over the 7-year period, sheep depredation losses to wolves were 3.5 times higher in the Non Protected Area than in the Protected Area. Furthermore, no wolves were lethally controlled within the Protected Area and sheep depredation losses to wolves in the Non Protected Area were just 0.02 % of total number of sheep present, the lowest loss rate among sheep grazing areas in wolf range statewide, while wolves were lethally controlled in the Non Protected area. Our demonstration project provides evidence that proactive use of a variety of nonlethal techniques applied conditionally can help reduce depredation on large, open range operations.

INFLUENCE OF MANAGEMENT-DRIVEN DISTURBANCE ON NORTHERN BOBWHITE SPACE USE AND NESTING ECOLOGY. James M. Carroll*[1], Torre J. Hovick[2], Craig A. Davis[1], R. Dwayne Elmore[1], Sam Fuhlendorf[1]; [1]Oklahoma State University, Stillwater, OK, [2]North Dakota State University, Fargo, ND

It is well supported that the composition and configuration of landscape mosaics resulting from fire contribute to avian community structure (i.e., species diversity and species richness). However, the mechanistic underpinnings of bird responses (e.g., life stage plasticity) to fire have been understudied, especially on dynamic disturbance-prone landscapes. We investigated covey home range and spring dispersal movements (2013-2014), as well as, nesting ecology (2012-2015) of northern bobwhite (*Colinus virginianus*; hereafter bobwhites) on an experimental landscape in western Oklahoma. Specifically, we assessed bobwhite responses to management-driven disturbance (i.e., prescribed fire) and environmental disturbance (ranging from extreme drought to above average precipitation). We found that time since fire (hereafter; TSF) influenced bobwhite covey home range size ($F_{4, 54} = 2.95$, $p < 0.05$) (n=61) which was characterized by smaller covey home ranges in 25-36 months TSF (52.07 ha [$\pm$ 6.6]) than in 0-12 (85.0 ha [$\pm$ 15.53]), 13-24 (86.7 ha [$\pm$ 20.7]) and >36 TSF (78.9 ha [$\pm$ 6.54]). Moreover, spring dispersal movements were not correlated with TSF (n=114) and plasticity in nest substrate use among TSF mediated nest survival (n=157) which was unaffected by TSF or weather parameters. As TSF increased, plasticity in nesting strategies were demonstrated by a linear increase and linear decrease in use of herbaceous and shrub nest substrates, respectively. Specifically, shrubs accounted for 72% of nest sites in 0-12 TSF, yet herbaceous cover accounted for 71% of nest sites in >36 TSF. Our findings highlight the interplay between landscape dynamics, disturbance, and ecology of a ground-nesting bird species on a fire-prone landscape. Moreover, these results show the importance of examining disturbance processes relative to the life stages of organisms, which is particularly critical given that restoring fire will be essential for limiting tree encroachment and promoting heterogeneity in rangeland ecosystems.

HABITAT AND SCALE: SPATIAL INFLUENCES ON NORTHERN BOBWHITE DENSITY. John T. Edwards*[1], Fidel Hernandez[2]; [1]Texas A&M University - Kingsville, Kingsville, TX, [2]Caesar Kleberg Wildlife Research Institute, Kingsville, TX

Habitat relationships of northern bobwhite have been developed based on research that historically has been conducted at a scale of high resolution (grain) but small extent. The relationships arising from such research trajectory therefore have been limited to study areas. Large-scale studies assessing bobwhite-habitat relationships recently have tried to overcome this limitation by increasing the extent; however, in doing so, there often has been a corresponding decrease in resolution. To effectively evaluate wildlife-habitat relationships, a study should seek to maintain the resolution of a small-scale study while simultaneously increasing the extent to that of a large-scale study. Although such an approach historically has been infeasible with prior field- and GIS-based methods, a high-grain/large-extent approach may be possible with recent developments in density surface modeling, which is a spatial extension of conventional distance sampling. This method utilizes information regarding probability of detection as well as geographic information, and can provide density estimates at high grains (<1 ha) across fairly large extents (>10,000 ha). Our objective was to investigate the spatial effects of habitat features on bobwhite density using a high-grain/large extent approach. We determined bobwhite density across 20,560 ha of rangeland within southern Texas utilizing a helicopter-based, distance sampling approach. We developed a binary classification of brush and open/herbaceous cover using National Agricultural Imagery Program aerial imagery. From this initial classification we were able to determine multiple metrics of habitat quality. We analyzed the effects of habitat features on bobwhite density using a density surface modeling framework, first fitting a detection function model to helicopter survey data, then fitting a density surface model, using individual habitat covariates as explanatory variables. Through this method we were able to estimate both bobwhite density and its relationship to habitat features at a high-grain across a relatively large extent.

NORTHERN BOBWHITE (*COLINUS VIRGINIANUS*) HABITAT SELECTION IN A LANDSCAPE AFFECTED BY ENERGY DEVELOPMENT. Cameron A. Duquette*, Craig A. Davis, Sam Fuhlendorf, R. Dwayne Elmore; Oklahoma State University, Stillwater, OK

The widespread popularity of energy extraction technologies such as hydraulic fracturing and horizontal drilling subjects grassland birds to additive habitat degradation through the fragmentation of these landscapes. Continuing development may contract suitable habitat for grassland birds, in turn exacerbating other stressors such as those caused by climate change. However, these same technologies allow greater flexibility of infrastructure placement, creating a unique opportunity for land managers faced with continued landscape alteration. Horizontal drilling allows for greater latitude in well pad placement, as a single well now has the capacity to serve multiple boreholes and extend in excess of 5km laterally. This allows managers to affect infrastructure configuration on the landscape, and thus the total area affected by extraction activities.

Using radiocollared northern bobwhite, we analyzed space use in the context of a suite of GIS-derived variables related to oil and gas development in a resource utilization function (RUF) framework. We found evidence of avoidance of well pads (β= -0.35982). Consistent with prior research, we found evidence of selection for areas closer to roads with fewer than 10 vehicle passes per day (β=0.376484). No significant selection was found for vegetation, anthropogenic viewshed, and nighttime radiance covariates. These results will allow land managers to address future development planning to minimize the loss of usable space for bobwhite due to energy infrastructure.

QUANTIFYING LANDSCAPE AND VEGETATIVE CHARACTERISTICS OF LESSER PRAIRIE-CHICKEN HABITAT DURING EXTREME TEMPERATURE EVENTS. Jonathan D. Lautenbach*[1], David Haukos[2]; [1]Kansas State University, Manhattan, KS, [2]U. S. Geological Survey, Manhattan, KS

As Earth's climate continues to change, temperatures are predicted to increase, increasing the number of days that species experience thermal stress. Thermal stress can negatively influences survival and reproduction for many wildlife species, including the lesser prairie-chicken (*Tympanuchus pallidicinctus*), an imperiled prairie-grouse native to the southwestern Great Plains. The Great Plains is considered a climate change hotspot, and is expected to see an approximate 10° C increase in average temperatures during spring and fall. Understanding how the species copes with intensifying conditions will help inform managers on how to create landscapes that minimize thermal stress. We captured female lesser prairie-chickens during the spring and attached transmitters to track their movements. We sampled vegetation and microclimate conditions using Maxim Integrated Semiconductors at lesser prairie-chicken midday loafing locations and random locations across the landscape to identify what vegetation characteristics and landscape features lesser prairie-chickens use to minimize thermal stress. We found that female lesser prairie-chickens selected cooler microclimates for daytime loafing compared to random points; up to 17° C cooler in some instances. Midday loafing locations averaged 2 times the amount of forb cover and nearly 1.5 times greater visual obstruction compared to random locations. Additionally, at the landscape scale we found aspect was an important component to thermal cover, as north aspects had cooler microclimates and lesser prairie-chickens disproportionally used this feature for midday loafing. Currently, lesser prairie-chickens seek thermal refugia during the hottest days (>30° C); with continued warming, the frequency and intensity of these days is predicted to increase, increasing the need for thermal refugia. Identifying a management practice that increases overall vegetation cover (visual obstruction) and spatially heterogeneity with an abundance of forbs will be important to provide important thermal refugia for lesser prairie-chickens.

THERMAL IMPACTS ON WILD TURKEY MOVEMENT AND SPACE USE . Allison Rakowski*, R. Dwayne Elmore, Craig A. Davis, Sam Fuhlendorf; Oklahoma State University, Stillwater, OK

Thermal environments place physiological and behavioral constraints on organisms. Ground nesting birds in the southern Great Plains are particularly vulnerable to temperature because of their predominately diurnal behaviors, nest location, and exposure to ambient temperature often exceeding 30C°. To better understand how organisms respond to thermal extremes, we assessed movement and space use of Rio Grande Wild Turkeys (*Meleagris gallopavo intermedia*; hereafter turkey) on Packsaddle Wildlife Management Area during June-August, 2016. We placed 20 backpack-style GPS transmitters on female turkeys. Each of the transmitters recorded 7 daytime locations (every 2 hours from 0800-2000) daily for 25 female turkey. We measured black ball temperature from (21°C-54°C), which incorporates both ambient temperature and the effect of solar radiation. Preliminary data indicates a tremendous thermal variation across the landscape. At an ambient temperature of ~34°C, black ball temperatures range from 30°C to 53°C, providing a. wide array (23°C) of thermal options to organisms. We also found that during peak heating (1200-1600 hours), locations where turkeys loaf (1400 hour turkey locations) were up to 6°C cooler than the locations at which turkeys feed (0800 hour turkey locations). Additionally, turkeys moved an average of 90m less between successive locations during the hours of peak heating (1200-1600 hours) on days >30°C than on days where temperature remained <30°C. These findings suggest that turkeys may be using the thermal variation across the landscape to help mitigate thermal extremes during the hours of peak heating and are modifying behavior to minimize exposure to high heat.

BEHAVIORAL RESPONSES OF GROUND-NESTING BIRDS TO THERMAL VARIATION DURING A CRITICAL LIFE STAGE. Rachel Beyke*, Craig A. Davis, Sam Fuhlendorf, R. Dwayne Elmore, Sarah DuRant; Oklahoma State University, Stillwater, OK

The thermal environment experienced by developing bird embryos is heavily influenced by parental decisions (i.e., nest site selection and incubation temperatures) that directly affect the growth and success of offspring. Furthermore, ground-nesting birds construct nests where thermal variability is greatest (i.e., ground-level) thereby elevating the effects of parental decisions. Therefore, it is important to identify the behavioral responses of ground-nesting birds to thermal variation to expand management practices for this critical life stage. Our objective was to investigate how two sympatric species existing on the edges of their continental distribution behaviorally adjust to local thermal environments and regulate incubation temperature. We assessed 44 scaled quail and 76 northern bobwhite nests at Beaver River Wildlife Management Area in the Oklahoma Panhandle, USA during 2015 and 2016. Incubation temperature (Ti), paired microsite (Tm) temperature, and nest site temperature (Tn) were assessed at 2 minute intervals. We observed that quail selected nest site locations that were cooler than the surrounding landscape (F_2, $30014=170.6$, p-value<0.05) by an average of 2.3°C during the heat of the day (14:00). Furthermore, Tn differed among nest substrate (F_2, $5201=45.88$, p-value<0.05), with yucca and herbaceous plants providing the coolest and warmest microclimates, respectively. Adult bobwhites regulated incubation temperatures by keeping nests cooler than the surrounding landscape during the afternoon ($T_1,27863=-$

91.151, p-value<0.05) (i.e., mean Ti of 35.3°C compared to mean Tm of 41.1°C), and warmer (T1, 73420=636.75,, p-value<0.05) than the surrounding landscape at night (i.e., mean Ti of 35.1°C compared to mean Tm of 21.9°C). Interestingly, vegetation visual obstruction and cover did not differ between successful and unsuccessful nests for either species, suggesting that nesting substrate and incubation behavior may be key drivers of nest microclimates. These results suggest that quail substantially modify the thermal environment that developing embryos experience and may shelter them from extreme conditions.

EFFECTS OF ENERGY DEVELOPMENT AND RANGELAND MANAGEMENT ON GREATER PRAIRIE-CHICKEN MOVEMENT AND SPACE USE . David W. Londe*, Sam Fuhlendorf, R. Dwayne Elmore; Oklahoma State University, Stillwater, OK

Greater prairie-chickens are a grassland obligate species that have been experiencing range wide declines over the last century. The Flint Hills region of Oklahoma and Kansas has one of the largest remaining population of greater prairie-chickens but the grasslands of this region are threatened with fragmentation from energy development and mismanagement of fire and grazing. Previous research has found that greater prairie-chickens are sensitive to fragmentation from energy development and require a variety of vegetative conditions that may be absent as a result of intensive cattle management practices such as extensive prescribed burns and high stocking rates. However, little information is available about how fragmentation and management influence movement and space use of greater prairie-chickens throughout the annual cycle. Step Selection Functions (SSF) offer an approach to analyzing the relationship between movement and resource use by comparing the characteristics of observed animal movements to unmade available movements. SSFs will be used to analyze how various environmental factors relating to energy development and rangeland management influence the movement patterns of female greater prairie-chickens in the southern Great Plains that were monitored using GPS transmitters over a two-year period. We predict that female greater prairie-chickens will make movements that keep them further from oil development and roads than expected, and that selection for time since fire and grazing will be dependent on the time of year.

RESOURCE SELECTION BY GREATER SAGE-GROUSE REVEALS PREFERENCE FOR MECHANICALLY-ALTERED HABITATS. Jared J. Baxter*[1], Rick J. Baxter[1], Dave K. Dahlgren[2], Randy T. Larsen[1]; [1]Brigham Young University, Provo, UT, [2]Utah State University, Logan, UT

Effective conservation requires an understanding of how species respond to management actions. For species of conservation concern such as greater sage-grouse (*Centrocercus urophasianus*), this understanding is urgently needed. We developed resource selection functions to assess the influence of mechanical treatments of mountain big sagebrush (*Artemisia tridentata vaseyana*) on habitat selection by greater sage-grouse during the

critical brooding period. We used model selection and a 19-year telemetry data set (1998-2016) to evaluate response of greater sage-grouse to treatments. Statistical models were built using 418 locations from 72 females with broods (333 locations, 61 females pre-treatment; 85 locations, 11 females post-treatment). Shrub canopy cover decreased (mean ± SE) from 31.81 ± 0.70% to 16.16 ± 0.89% following mechanical treatment ($P < 0.05$). Grass cover increased from 12.02 ± 0.51% to 31.33 ± 1.52% after treatment ($P < 0.05$). Post-treatment forb cover (12.58 ± 1.23%) did not differ from pre-treatment estimates (12.39 ± 0.61%; $P = 0.98$). Overall, greater sage-grouse selected areas that were 1) farther from trees, paved roads, and powerlines, 2) higher in elevation, 3) nearer treatment edges, and 4) consisting of gentler slopes. Post-treatment sage-grouse showed stronger selection for areas near treatments than did pre-treatment sage-grouse. Maps predicting probability of selection by brood-rearing sage-grouse showed increased use in and around mechanically-treated areas. This altered pattern of selection by sage-grouse with broods suggests mechanical treatments may be a suitable way to increase use of mountain big sagebrush during the brooding period.

EXTENDING STATE-AND-TRANSITION MODELS TO INCLUDE WILDLIFE ECOSYSTEM SERVICES. Jennifer Timmer*[1], Retta Bruegger[2], Maria Fernandez-Gimenez[3], Cameron Aldridge[4]; [1]CSU, fort collins, CO, [2]Colorado State Extension, Grand Junction, CO, [3]Colorado State University, Fort Collins, CO, [4]CSU, USGS, Fort Collins, CO

State-and-transition models (STM) represent a fairly new approach to describe range dynamics with multiple stable states. STMs can be improved by including multiple sources of information, such as ecological data and local knowledge, and by addressing multiple ecosystem services. By including additional services in the models, such as wildlife habitat, land managers could predict how wildlife populations might change in response to vegetation dynamics and drivers of change like fire or grazing. Our objective was to incorporate avifauna abundance data into locally-developed STMs for dominant ecological sites in sagebrush rangelands in northwest Colorado. We stratified our study area by ecological site, or where developed ESDs were lacking, by sagebrush cover and elevation. We surveyed randomly distributed plots for songbirds and greater sage-grouse (*Centrocercus urophasinus*) pellets, collected a suite of vegetation and soils data at each plot, and developed STMs based on multivariate analyses and local stakeholder input. To predict avifauna abundance per state, we developed count-based regression models with the vegetation data as predictor variables, and predicted the count of songbirds and sage-grouse pellets based on average predictor values per state. One STM included two shrub states, a native grassland state, and a crested wheatgrass (*Agropyron cristatum*) dominated state. We predicted higher abundances for sagebrush and shrub-obligate species in either the diverse shrub or crested wheatgrass-dominated state and the least in the native grassland state. Conversely, the native grassland state provided greater abundances of non-shrub-obligate species. Our models can assist local land managers and landowners to gauge impacts of land-use decisions on avifauna populations.

Oral Technical Session:
Vegetation Management and Restoration I

NEW 'FLASH FLAMING' TECHNIQUE IMPROVES SEED HANDLING AND COATING POTENTIAL OF DIFFICULT-TO-HANDLE GRASS SPECIES. Todd E. Erickson*[1], Andrew L. Guzzomi[2], Miriam Muñoz-Rojas[3], Shane R. Turner[3], David J. Merritt[4]; [1]Project Manager, Restoration Seedbank Initiative, Perth, Australia, [2]Asst/Prof, Perth, Australia, [3]Research Fellow, Perth, Australia, [4]Senior Research Scientist, Perth, Australia

Poor rehabilitation outcomes in the mined drylands of northern Western Australia have recently been highlighted by the state's EPA, stating that the required biodiversity values of undisturbed ecosystems are not being reinstated to the agreed upon standards. In this region, for example, rehabilitation has been reported to achieve <15% of the pre-mined plant cover and density values. This alarming scenario is repeated across most Australian and overseas landscapes that have been degraded by intense human land-use. These rehabilitation shortfalls result from a poor understanding of native seed biology and the inability to effectively deliver seeds at scale. Under current practices over 90% of seeds fail to establish into a mature plant.

In recent years, we have focused on seed enhancement technologies to overcome these shortfalls which involve novel, biologically-guided engineering solutions for precision delivery of seeds that are tailored to site-specific conditions to improve plant survival. Such improved, large scale machine seeding and engineering solutions have direct application to the rehabilitation of degraded lands.

In this presentation we will demonstrate the benefits of our Australian 'flash flaming' invention that removes unwanted seed appendages that impede automated seeding at large scales. This invention delivers significant seed volume and weight reduction, and improved application of artificial seed coatings that are used extensively in agriculture. Such coatings can be adapted to native seeds to facilitate precision, machine sowing and increase germination and survival, and overcome many aspects limiting the use of difficult to handle seeds in global rehabilitation programs.

THE USE OF PREDICTIVE MODELING TO ESTABLISH THE PRACTICALITY OF COATING SEEDS WITH ABSCISIC ACID. William C. Richardson*, Matthew Madsen, Karma Phillips, Bruce Roundy, Dallin Whitaker; Brigham Young University, Provo, UT

Due to the extensive impact that wildfires can have and the slow recovery of the ecosystem, it is common practice to re-seed the affected area in the fall with native seed species in the hope of reducing weed dominance. Abscisic acid (ABA) could be used in the coating of rangeland seeds and delay germination until spring when environmental conditions are more suitable for seedling establishment. We evaluated how 7 different ABA seed coating rates influenced seed germination timing of bluebunch wheatgrass at 5 different temperatures. Wet thermal accumulation models were then developed to predict

seed germination timing. These models use curvilinear equations where the germination rate (inverse time to 50% germination in a population) is a function of soil temperature. These equations were applied to historical field temperature and moisture data from various sites in the Great Basin to estimate germination timing and establish the practicality of ABA coatings as a conservation practice. The historical field data was taken from the Sagebrush Steppe Treatment Evaluation Project (SageSTEP). This information has been gathered over a 10-year period from 19 different sites. Germination models applied to SageSTEP data predicted that application rates of 2.2 g or greater of ABA kg-1 of seed was sufficient to delay germination of October planted seed until the end of March. Field research is needed to verify the accuracy of ABA seed germination models and evaluate if the technology will improve seedling establishment.

NOVEL TECHNIQUES FOR ENHANCING NATIVE FORB GERMINATION AND ESTABLISHMENT ON GREAT BASIN RANGELANDS. Adam Fund*[1], Kristin Hulvey[1], Douglas A. Johnson[2], Derek Tilley[3], Scott Jensen[4], Matthew Madsen[5]; [1]Utah State University, Logan, UT, [2]USDA ARS Forage and Range Research Lab, Logan, UT, [3]NRCS Aberdeen Plant Materials Center, Aberdeen, ID, [4]USFS Provo Shrub Sciences Lab, Provo, UT, [5]Brigham Young University, Provo, UT

Public land management agencies, conservation organizations, and landowners are interested in expanding the biodiversity of rangeland plantings. While the establishment of native grasses and shrubs on Great Basin sage-steppe sites is increasingly successful, the establishment of native forbs remains notoriously low. In the Great Basin, this could be due to low soil water, fluctuating soil temperatures, and soil pathogens. We compared the efficacy of two main treatments for enhancing native forb germination and establishment: snow fences and N-sulate fabric. We replicated these treatments plus a no-treatment control across three sites in the Great Basin (two in Utah, one in Idaho) in a randomized complete block design. Sites spanned a latitudinal gradient to encompass different precipitation and temperature regimes. Within main treatments, we additionally examined whether fungicide and hydrophobic seed coatings enhanced germination and seedling establishment. We tested the effects of treatments on 12 native forb species. We determined germination via buried germination bags, and we counted seedlings monthly from March to July 2016. Seed coatings generally increased germination at all sites, suggesting that fungicide and hydrophobic coatings provide an advantage that is sustained across latitudinal gradients. The effect of snow fence and N-sulate treatments on actual seedling establishment varied by site, with snow fences increasing establishment at the most southerly site, and N-sulate increasing establishment at one of the two northerly sites. Despite the increase in establishment at some snow fence and N-sulate treatments, densities of established native forbs remained low across treatments. Our findings suggest that while restoration treatments that alter biotic and abiotic conditions can enhance native forb germination and establishment in the Great Basin, additional work is needed to increase total establishment rates.

LETHAL DOSE (LD50) AND GROWTH REDUCTION (GR50) BY GAMMA RADIATION ON LEHMANN LOVEGRASS (*ERAGROSTIS LEHMANNIANA* NESS). Alan Alvarez*, Carlos Morales, Raúl Corrales, Federico Villarreal; Universidad Autónoma de Chihuahua, Chihuahua, Mexico

Lehmann lovegrass (*Eragrostis lehmanniana*) is a species that despite the fact that being invasive is used in grasslands revegetation programs. However before of use it, is important to improve its livestock intake and with that reduce its invasiveness. The medium lethal dose (LD50) and growth reduction dose (GR50) are measurements used to determine proper radiation doses for plants genetic improvement programs conducted through mutagenesis. The objective of this study was to determinate the LD50 and the GR50 on lehmann lovegrass (*Eragrostis lehmanniana*). The variables evaluated were germination percentage (GP), germination speed index (SGI), plumule length (PL), radicle length (RL), forage yield (FY), seed production (SP), stems number (SN), plant height (PH), tillering deiameter (TD) and chlorophyll concentration index (CCI). Data were analyzed through a trend analysis for each variable. With the resulting regression equation the LD50 were estimated based on GP and the GR50 based on SGI, PL, RL, FY, SP, SN, PH and CCI. In addition, data were analyzed through means comparison with the Dunnett's test. Also, with the results obtained for LD50 and GR50 there a weighted average was calculated. Most of the variables evaluated did not show effects (P>0.05) under radiation exposures of doses lower than 1400 Gy. Moreover, germinated seeds that were exposed at 2000 Gy did not survive more than 21 days. The LD50 on lehmann lovegrass was found at 2076 Gy, while the GR50 ranged between 1357 and 1900 Gy. Therefore, for the genetic improvement of this species is recommended to use the weighted average obtained from both parameters, such average was found at 1533 Gy.

MEDIUM LETHAL DOSE (LD50) AND GROWTH REDUCTION (GR50) OF ARID LAND GRASSES WITH GAMMA RADIATION. Raúl Corrales, Alan Alvarez, Carlos Morales, Federico Villarreal*; Universidad Autónoma de Chihuahua, Chihuahua, Mexico

The mediun lethal dose (LD50) and growth reduction (GR50) are measurements used to select appropriate irradiation doses to induce mutations in plant breeding programs. The objective of this study was to determine the LD50 and GR50 in blue grama (*Bouteloua gracilis*), sideoats grama (*Bouteloua curtipendula*), Buffel grass (*Pennisetum ciliare*) and weeping lovegrass (*Eragrostis curvula*). For that, seven irradiation doses over the seed were evaluated and included 0 (T-0), 100, 200, 300, 450, 600 and 900 Gray (Gy). The variables evaluated were germination percentage (% GE), germination rate index (GRI), plumule length (PL) and radicle length (RL). Data were analyzed using the GLM procedure available in the SAS software through trend analysis and comparison of means with the Dunnett's test. The % GE, GRI, PL and RL of sideoats grama, weeping lovegrass and buffel grass decreased (P <0.05) as the radiation dose increased. However, GE %, GRI and LP of blue grama showed an increase (P <0.05) at doses of 100, 200 and 300 Gy. In weeping lovegrass LD50 was estimated to be at 565 Gy, while the GR50 ranged from 490 to 867 Gy. In buffel grass LD50 was found to be 625 Gy and GR50 varied between 542 and 985 Gy. The LD50 in sideoats grama was found at 443 Gy, while its

GR50 fluctuated between 406 and 1248 Gy. In blue grama LD50 was obtained at 398 Gy and GR50 ranged from 323 to 447 Gy. In these species, the doses between 100 and 300 Gy of gamma radiation can stimulate the capacity and speed of germination and plumule development.

USING CONNECTIVITY MODIFIERS TO RESTORE DEGRADED GRASSLANDS IN CANYONLANDS AND ARCHES NATIONAL PARKS. Rebecca K. Mann*[1], Michael C. Duniway[1], Liz Ballenger[2], Mark E. Miller[2]; [1]US Geological Survey, Moab, UT, [2]NPS, Moab, UT

Due to historic over grazing, many grasslands on the Colorado Plateau have been converted to degraded plant communities with extensive patches of bare ground and a predominance of annual invasive plants such as cheatgrass (*Bromus tectorum*) and Russian thistle (*Salsola tragus*). These areas have undergone an ecological state shift, and are associated with processes that prevent their natural recovery, including accelerated rates of soil erosion and overland water flow, depleted native seed banks, and loss of surface soil quality. In arid regions with highly variable precipitation, drill seeding and other traditional methods of rangeland restoration can exacerbate erosion and often have only marginal success in seeded plant establishment.

Our work in Canyonlands and Arches National Parks involves testing and deploying a novel restoration technique that is designed to overcome harsh physical site conditions while minimizing overall site disturbance. Connectivity Modifiers (ConMods) are 45 cm-long fencing structures that create microsites favorable to seedling establishment by blocking wind, creating shade, and capturing sediment and organic matter. Previous research in Canyonlands has shown that after four years, 90% of ConMods seeded with native perennial grasses had successful establishment, significantly greater than areas which were seeded without ConMods. We subsequently initiated a study within four heavily degraded sites to investigate the effects of ConMod density on restoration at the patch scale (e.g. establishment of desired species between ConMods). Over 2,500 ConMods have been installed as part of this adaptive management effort and restoration success will be monitored over several years. This research is expected to inform and potentially optimize restoration strategies used by the National Park Service in degraded grasslands, and provide a better understanding of how physical structures can be used to moderate harsh microsites and increase likelihood of seeded plant establishment.

IMPACT OF ANNUAL RYEGRASS SEEDING ON INVASIVE GRASS POPULATIONS AND GRAZING VALUE ON CALIFORNIA ANNUAL GRASSLAND. Larry C. Forero*[1], Josh S. Davy[2], Jeremy James[3], Philip Brownsey[4]; [1]UC Cooperative Extension, Redding, CA, [2]University of CA, Red Bluff, CA, [3]UCCE Sierra Foothill Research and Extension Center, Browns Valley, CA, [4]Independent Consultant, Sacramento, CA

Foxtail (hare barley) and medusahead adversely affect rangeland forage quality across much of California's annual rangeland. This project used yearling cattle to evaluate the economic utility of replacing foxtail and medusahead dominated pastures with ryegrass, a much preferred forage species. We created three replicated experimental pastures and three adjacent equal sized controls. Treatment plots received a fall glyphosate treatment and light disking prior to planting. Then were seeded with Gulf annual ryegrass at 20 lbs/acre, and harrowed to cover the seed. Cattle were weighed and introduced to the plots in March. Grazing continued until June when forage quality diminished due to drying. Grazing metrics included cattle gain and AUM harvest. Forage biomass, species composition and quality data were collected. Costs were calculated and economics considered in the analysis.

GRASS SEEDLING GROWTH AND SURVIVAL UNDER DIFFERENT POST-FIRE GRAZING MANAGEMENT SCENARIOS. Jeffrey M. Gicklhorn*[1], Beth A. Newingham[2]; [1]University of Nevada, Reno, Reno, NV, [2]USDA-ARS, Reno, NV

As wildfires have increased in frequency and size throughout the Great Basin, post-fire rehabilitation activities have become important in reestablishing resilient sagebrush steppe communities. Many rehabilitation treatments fail when perennial grass seedlings do not establish. This can be due to pre-fire site condition, burn severity, and presence of non-native species, which leads to varying post-fire biotic and abiotic conditions. Domestic livestock grazing presents a further challenge to seedling establishment after fire with pressure to reintroduce grazing as early as possible. There is little research addressing the question of when is ecologically appropriate to re-implement livestock grazing after wildfire in sagebrush ecosystems, and none addressing grazing impacts to seedlings planted in rehabilitation treatments. We examined the effect of varying seedling and adult plant density and timing of post-fire grazing on relative growth rates, survival, and canopy cover of perennial grass seedlings in Wyoming big sagebrush (*Artemisia tridentata ssp. wyomingensis*) communities. We analyzed within season plant growth rates using a non-linear mixed model approach, and end of season plant density and cover using a linear mixed model approach. Spring grazing resulted in faster within season growth rates as compared to no grazing and fall grazing. Adult and seedling removal treatments resulted in lower plant density, while only seedling removal resulted in lower plant cover as compared to no plant removal. Timing of grazing had no effect on plant density or percent cover.

EFFECTS OF TRAMPLING AND COVER ON RECRUITMENT OF RESEEDED GRASSLANDS AND BULK DENSITY OVER TIME. Kathryn L. Radicke*[1], Tim Steffens[2], Kim Peters[2], Marty Rhoades[1], David Lust[1], Brock Blaser[1], Matthew Ham[1]; [1]West Texas A&M University, Canyon, TX, [2]West Texas A&M, Canyon, TX

Trampling may enhance soil seed contact and increase surface roughness, thereby potentially enhancing seedling germination and survival, particularly if litter cover is

increased to prolong soil moisture in the upper 2.5cm of the soil profile (Winkel and Roundy, 1991). To test this hypothesis, we broadcasted Green Sprangletop (Leptocloa dubia) and Kleingrass (Panicum coloratum) seed at approximately 4.5 kg Ha-1 PLS each on former cropland that had been unsuccessfully seeded to plains bluestem (Bothriochloa ischaemum). Four 0.1 ha plots were trampled by placing yearling heifers at high stocking densities (90,702 kg live wt ha-1) for 12 hours following a rainfall event of 4.3 cm to enhance soil-seed contact and put standing plant material in contact with the soil, while 4 adjacent control plots of the same size were left untrampled. After trampling, we scattered Sorghum-Sudangrass hay on portions of the untrampled and trampled treatment plots to achieve 100% soil surface cover. We then provided extended grazing deferment to determine if trampling and/or enhanced litter cover would have an effect on seedling establishment and total vegetative cover. Before trampling and after precipitation events, six Daubenmire frames were randomly placed in each treatment plot to determine foliar, basal, litter, and total cover. Trampled treatments had less vegetative cover ($P<0.01$) and average soil bulk density was higher ($P<0.01$) than untrampled plots immediately after trampling. Significant recruitment of Green Sprangletop and/or Kleingrass did not occur. Additionally, there were no differences in cover amount, species, or seedling recruitment between trampled and untrampled plots since plains bluestem cover increased in both grazed and ungrazed treatments to a similar degree. However, there were differences in foliar cover and seedling frequency in the supplementally covered versus no covered treatments ($P<0.05$), indicating that high levels of vegetative litter cover after a high stocking density grazing is important for range improvement.

GERMINATION, GROWTH, AND SURVIVAL OF CHIHUAHUAN DESERT NATIVE PLANTS WITH FOUR WET-DRY SEQUENCES. David E. Prado-Tarango*[1], Alicia Melgoza[2], Ricardo Mata-Gonzalez[1], Sabry G. Elias[1], Eduardo Santellano[2]; [1]Oregon State University, Corvallis, OR, [2]Universidad Autonoma de Chihuahua, Chihuahua, Mexico

We conducted a germination test with four moisture patterns as a base for a propagation protocol for native Chihuahuan Desert plant species. These moisture patterns were wet-dry sequences following precipitation characteristics of the Chihuahuan desert. The patterns were: a) High (12 wet days per month), b) Medium (10 wet days per month), c) Low (8 wet days per month) and d) Lowest (6 wet days per month). Each pattern was tested for one month and the rest of the days were treated as drought. The evaluated species were *Menodora scabra* A. gray., *Yucca elata* (Engelm.) Engelm., and *Zinnia grandiflora* Nutt. First, we tested the viability/dormancy of the seeds with a tetrazolium and germination test. The results showed that *M. scabra* had the highest viability, followed by *Y. elata* and *Z. grandiflora* (91%, 87%, and 39% respectively). The germination tests indicated no seed dormancy in any species given the successful seed germination under laboratory conditions. Furthermore, seed germination of the three species (86%, 84%, and 20%) was highly related to seed viability. We also evaluated the germination, survival and growth of the three species under the four wet-dry sequences in the greenhouse. Results showed no germination differences among the high, medium and low sequences for both *M. scabra* and *Z. grandiflora.* Only the lowest irrigation sequence

produced less germination than the other wetter sequences in both *M. scabra* and *Z. grandiflora*. In *Y. elata*, germination was not affected by treatments. Even the lowest irrigation sequence produced satisfactory germination. Also, the survival of all the species by the end of the experiment was not affected by treatments. Results indicate that *Y. elata* would germinate and survive in any of our treatments while the other species would require years with special rainfall conditions.

SEEDLING DEVELOPMENT OF NATIVE GRASSES SPECIES ACCORDING TO SERAL STAGE. Aldo Sales*[1], Carlos Villalobos[2]; [1]Texas Tech University, Lubbock, TX, [2]Texas tech university, Lubbock, TX

In the last years there has been an increasing number of reports showing failures in the re-seeding of rangelands with native or introduced grasses. This study was conducted to evaluate the germination, survival, and morphological development of seedling rangeland grasses according to seral stages. The study was conducted in germination chamber conditions with sunlight simulation (12 hours-day), temperature (Day 33oC/Night 25oC), and air-humidity (60%). There were evaluated two cycles in three species per each seral stage (early, mid and late). There were used pots filled with sterilized sand soil (123.31 cm3), which were watered daily with deionized water with Hoagland solution. Each pot was divided into four quadrants, and three seeds were placed in each quadrant. Daily we evaluated the germination rate and each four days we measured the morphogenesis of 36 seedlings. We repeated the procedure 12 times. In total, we analyzed 432 seedlings for each seral stage. For morphogenesis analyses, the seedlings were washed from the pots with cold water and measured the following variables: Shoot length (mm), number of adventitious roots, the length of seminal and adventitious roots (mm). The data was subjected to analysis of variance and means were compared by Tukey test ($P<0.05$). On average, less of 4% of late seral species reached juvenile phase; we addressed that failures in the establishment were caused by a low proportion of adventitious roots. Early and late seral species showed a morphological biomass allocation marked by times of more root growth and times of more biomass allocation to the shoot. In conclusion, germination is not a good indicator of success in the re-seeding; and re-seeding with late seral species is a practice with low chances of success due to a high mortality of seedlings in the juvenal phase.

Symposium:
Sagebrush Restoration

SAGEBRUSH: FROM MANAGING A "WEED" TO RESTORING AN ECOSYSTEM. Mike L. Pellant*; BLM, Boise, ID

In 1848 early Intermountain explorer John Freemont portrayed the valleys in the Great Basin as "sterile" and characterized this landscape as, "...no wood, no water, no grass, the gloomy artemisia the prevailing shrub...". This unenthusiastic perception of big

sagebrush (Artemisia tridentata) continued through the first half of the 21st century as land managers struggled to reduce the dominance of sagebrush, frequently described as a weed, and increase desirable herbaceous grasses. The pendulum changed direction in the 1970's with the passage of several environmental laws and a growing recognition of the ecological values of sagebrush. Increasing losses of sagebrush due to wildfires and cheatgrass (Bromus tectorum) contributed to a change in management priorities away from removing to restoring sagebrush across the Great Basin. The majority of sagebrush applied by the Bureau of Land Management is aerially seeded the fall or winter following a wildfire. Using this technique, large acreages can be economically seeded yielding variable results. In general, marginal results are more common in the lower elevation Wyoming big sagebrush biome. Establishment is improved when using ground-based seeding equipment that firms the seedbed and utilizing local seed sources. Another challenge is prioritizing burned areas for sagebrush seeding given the increase in rangeland mega-fires and management emphasis on conserving and restoring Greater Sage-Grouse habitat. A landscape scale procedure (Fire and Invasive Assessment Tool) was developed by the management agencies and the research community to prioritize post-fire rehabilitation in Greater Sage-Grouse habitat using resistance to invasive annual grasses and resilience after disturbance concepts.

SHORT-TERM VEGETATION RESPONSE TO MOWING AND HERBICIDE TREATMENTS IN WYOMING BIG SAGEBRUSH. Jeffrey L. Beck*, Jason R. LeVan, Kurt T. Smith; University of Wyoming, Laramie, WY

Wyoming big sagebrush (*Artemisia tridentata wyomingensis*) has been historically treated through chemical application, mechanical treatments, and prescribed burning to increase the amount and quality of herbaceous forage available to wildlife and livestock. Treatments are often intended to rejuvenate sagebrush stands by killing older sagebrush plants to promote growth of younger sagebrush plants and increase resources for herbaceous production. We evaluated the vegetation response of mowing and herbicide treatments in Wyoming big sagebrush habitats in central Wyoming as part of a larger study to evaluate how sagebrush treatments influence habitat selection and demographic parameters of greater sage-grouse (*Centrocercus urophasianus*). Mowing and Spike® 20P treatments were applied in the winter and spring of 2014, respectively. We installed exclosures to exclude livestock from treated and paired untreated sagebrush. Shrub characteristics, grass height, herbaceous canopy cover, and ground cover were evaluated at treated and untreated sagebrush in 24 exclosures that excluded livestock grazing and at 100 treated and untreated areas where livestock grazing occurred from 2014 to 2016. Vegetation characteristics were estimated along two perpendicular 30-m transects centered at each location and followed protocols similar to those used to evaluate sage-grouse microhabitat selection. As expected, treatments resulted in a reduction in sagebrush cover and height; however, herbaceous understory response was variable and often mimicked untreated reference locations in both grazed and un-grazed locations. Our results corroborate other studies that suggest treating Wyoming big sagebrush communities does not often result in short-term increases in herbaceous understory.

RESPONSES OF SAGEBRUSH COMMUNITIES TO MULTIPLE DRIVERS OF CHANGE. Claire E. Wainwright*[1], Jonathan Bakker[2]; [1]University of Washington, Seattle, WA, [2]School of Environmental and Forest Sciences, University of Washington, Seattle, WA

Sagebrush steppe ecosystems provide valuable rangeland and biodiversity conservation habitat in the western U.S. Remaining sagebrush steppe communities are subject to multiple anthropogenic disturbances including overgrazing and invasion by exotic annual grasses, which has shortened fire return intervals. Management decisions in these communities would be simplified if it was possible to identify past interactions between site attributes and disturbance types that predispose certain areas to degradation.We explored compositional change from 1991-2002 in sagebrush steppe communities on the Yakima Training Center (YTC) in central Washington state. Data were drawn from permanent plots established across YTC through the Land Condition Trend Analysis program. Communities varied in initial species composition and extent of invasion, and also spanned a large spatial extent, enabling examination of change along edaphic and elevational gradients. We related multivariate community responses to yearly climate, grazing pressure, fire history, and military disturbance. Specifically, we used multivariate control charts to identify transitions away from baseline conditions. Though restoration activities were sparse during the 1990s, this approach would also be suited to examining responses to restoration if conducted at large enough scale.

Overall, we found strong evidence that sensitivity to drivers was contingent upon initial species composition and environmental conditions. On average, low elevation communities dominated by exotic annuals experienced the greatest change over time, while higher elevation communities (typically comprising more intact sagebrush and bunchgrass-forb associations) were more resistant to change. Fire responses were greatest in these low elevation exotic communities, which tended to become more invaded over time. Compositional change appeared to track patterns in precipitation over the study period, but was exacerbated by grazing pressure and disturbance from military training activities. In light of these results, we discuss options for conservation of intact communities and prioritizing restoration in vulnerable communities that may require the most active management inputs.

RESTORING MOUNTAIN BIG SAGEBRUSH AFTER FIRE IN WESTERN JUNIPER-ENCROACHED RANGELANDS. Kirk W. Davies*[1], Jon Bates[2]; [1]USDA - Agricultural Research Service, Burns, OR, [2]USDA - ARS, Burns, OR

In the western USA, restoration of mountain big sagebrush (*Artemisia tridentata* Nutt. ssp. *vaseyana* (Rydb.) Beetle) after fire has controlled encroaching western juniper is a priority to improve sagebrush-associated wildlife habitat. We evaluated restoring mountain big sagebrush in four different studies. In general, we found that seeding

mountain big sagebrush accelerated sagebrush recovery. Some sites had greater than 30% sagebrush cover by the fifth year post-fire. The benefit of seeding sagebrush was most evident on burned Phase III juniper encroached rangelands were natural recovery was slow. Sagebrush recovery with and without seeding was highly variable across large heterogeneous landscapes. For example, sagebrush density was 40 times greater north slopes compared to south slopes. We also found that seeding mountain big sagebrush several years after fire was generally unsuccessful. Competition from herbaceous vegetation likely decrease the establishment and growth of seeded sagebrush. Thus, its likely important to seed sagebrush prior to the first growing season after fire. In areas where sagebrush habitat is limited, seeding mountain big sagebrush after fire in juniper-encroached rangelands may decrease the risks to sagebrush-associated wildlife.

ESTABLISHING SAGEBRUSH IN SHRUB-DEPLETED SITES IN NORTHERN NEVADA. Kent McAdoo*[1], Chad Boyd[2], John Swanson[3], Nancy Shaw[4]; [1]University of Nevada Cooperative Extension, Elko, NV, [2]USDA-Agricultural Research Service, Burns, OR, [3]University of Nevada, Reno, NV, [4]U.S. Forest Service (retired), Boise, ID

Recent studies in northern Nevada have underscored the difficulties of establishing Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*) in shrub-depleted areas. One study evaluated the survival of sagebrush transplants at each of three sites: 1) cheatgrass (*Bromus tectorum*)-dominated, 2) native grass-dominated, and (3) crested wheatgrass (*Agropyron desertorum)*-dominated. Sagebrush density at one and two years post-planting was generally highest (up to 3-fold) on the native site. Glyphosate application for herbaceous reduction increased surviving sagebrush density up to 300% (depending on site). Significantly greater volume of surviving sagebrush plants in plots treated with glyphosate suggested substantially increased production of sagebrush transplants with reduced herbaceous competition. During another study, over a 5-year period we evaluated chemical and mechanical methods for reducing crested wheatgrass and the effectiveness of seeding native species into these sites. Discing treatments were ineffective in reducing crested wheatgrass. Glyphosate treatments initially reduced crested wheatgrass cover, but weeds increased in many treated plots and seeded species diminished over time as crested wheatgrass recovered. Although sagebrush establishment from seed was very weak (<0.1 shrub/m2) and there were no significant differences among treatments by the end of the study, the few sagebrush that survived in areas where crested wheatgrass had been initially reduced may be ecologically important nevertheless. Herbaceous species are highly competitive with sagebrush during the first season of establishment, but after sagebrush has established it has high persistence in crested wheatgrass communities due to niche differentiation between these species. The addition of sagebrush into shrub-depleted former big sagebrush communities leads to greater diversity of habitat structure important to a variety of wildlife species. Although sagebrush establishment from transplants can be implemented successfully with reduction of herbaceous competition, the practical and economic limitations of this technique are obvious. Therefore, the need for improving sagebrush survival from seed

remains paramount.

RESTORING SAGEBRUSH AFTER MEGA-FIRES: SUCCESS OF DIFFERENT RESTORATION METHODS ACROSS AN ELEVATION GRADIENT. April Hulet*[1], Kirk W. Davies[2], Matthew Madsen[3], Chad Boyd[4], Michael Gregg[5]; [1]University of Idaho, Moscow, ID, [2]USDA - Agricultural Research Service, Burns, OR, [3]Brigham Young University, Provo, UT, [4]USDA-Agricultural Research Service, Burns, OR, [5]US Fish and Wildlife Service, Richland, WA

Sagebrush restoration after wildfires has had limited success, and success likely varies considerably by method, site characteristics and interactions between them. Our objective was to compare different sagebrush restoration methods (broadcast seeding, broadcast seeding and packing, planting sagebrush seedlings, seed pillows, and natural recovery) across elevation gradients ranging from 1219 to > 2134 m (4000 to 7000 ft). We used 350 plots spread across approximately a million acres of sagebrush rangelands in Oregon that burned in two mega-fires in 2012. All sagebrush restoration methods were seeded in the fall of 2013, and then repeated on adjacent plots in 2014 with the exception of sagebrush seedlings; sagebrush seedlings were planted in the spring of 2014 and 2015. For Wyoming big sagebrush plots (elevation 4000 to 5000 ft), plots seeded in the fall on 2013 had on average < 0.01 sagebrush plants/m² for all restoration methods. Plots seeded in the fall of 2014 had an average of 12.0 sagebrush plants/m² (natural recovery plots had 0.2 sagebrush plants/m²). Precipitation was on average 4% less than the 30 year average between September 2013 and August 2014; however, between September 2014 and May 2015 precipitation was on average 36% greater than the 30 year average. For mountain big sagebrush plots (elevation 5500 to 7000 ft), seeded plots were on average 4-fold greater than natural recovery plots (5.3 vs 1.2 plants/m²) for both seeded years. Perennial bunchgrass competition with sagebrush seedlings may have influenced sagebrush densities particularly in higher elevation plots; mountain big sagebrush plots had on average 7.8 plants/m², whereas Wyoming big sagebrush plot had on average 1.1 plants/m². Data is being further analyzed based on a suite of environmental characteristics with the expectation that this information will help land managers successfully restore sage-grouse habitat after wildfires by pairing restoration methods with site characteristics.

RESTORATION TECHNIQUES TO INCREASE SURVIVAL AND VIGOR OF FOUNDATION SHRUB SPECIES IN A SEMI-ARID SYSTEM. Amy P. Jacobs*[1], Peter Stahl[2]; [1]University of Wyoming, Laramie, WY, [2]Wyoming Restoration & Reclamation Center, Laramie, WY

Efforts to restore burned Wyoming big sagebrush (Artemisia tridentata ssp. wyomingensis Beetle & A.W. Young) populations are frequently unsuccessful due to the inability of sagebrush seedlings to compete with established grasses, which are not killed by fire. Current best management practices used to curb competition typically include

seeding of native perennial grasses and use of herbicides. The objective of my study focuses on the efficacy of mechanical suppression of grasses competing with planted sagebrush seedlings using various mulch treatment types. My study site is located in a burned Wyoming big sagebrush landscape in Converse County, Wyoming. Approximately 10,900 container grown Wyoming big sagebrush were transplanted into 115 plots (95 m2). Each plot was planted exclusively using one of five mulch treatments with 95 seedlings per plot. Transplants were planted in uniform rows with 2 m separation between each. The objective of my research is to quantify the effects of different mulch treatments on improving sagebrush transplant survivorship, fitness, and above ground growth. Preliminary results indicate that treatment types have a significant effect on survivorship and an even more significant effect on crown volume (up to 400%). Research methodology and results will be expanded upon at time of presentation.

NOVEL SEED TECHNOLOGIES TO ENHANCE WYOMING BIG SAGEBRUSH SEED DELIVERY AND PERFORMANCE . Matthew Madsen*, Ryan Call, Thomas Bates, William C. Richardson, Karma Phillips, Thomas Whitlock; Brigham Young University, Provo, UT

To sustain North America's declining sagebrush biome, novel approaches are needed that can cost-effectively restore shrub cover after a catastrophic disturbance, such as a high-intensity wildfire. Wyoming big sagebrush is a dominant shrub on the more arid portions of the sagebrush biome and seeding efforts of this species are limited by a host of logistical and environmental constraints. Sagebrush seed lots are typically low in purity and can contain a high amount of non-seed parts (i.e. achenes, seed bracts, leaves, and fine stems), which can cause bridging within the seed box and variable delivery rates from a planter or broadcast spreader. The small seed size of sagebrush tend to separate from other species in the mix while in the seed box and when broadcast, drift from the target area. As with many species sown for restoration in the Great Basin, mortality may result when the seed germinates during a period that is not suitable for plant survival. We have developed a new seed coating technique that increases sagebrush seed density, improves flowability and seed delivery. Seed enhancements such as fungicides and plant growth regulators can also be formulated into the technology to control seed germination timing so that it occurs during periods that are more optimal for plant establishment. We will present preliminary research associated with the development of this patent pending technology and discuss its potential benefits for improving rangeland seeding success.

PREEMPTIVE MANAGEMENT FOR RESILIENT SAGEBRUSH PLANT COMMUNITIES TO REDUCE THE NEED FOR RESTORATION. Chad S. Boyd*[1], April Hulet[2], Kirk W. Davies[3]; [1]USDA-ARS, Burns, OR, [2]University of Idaho, Moscow, ID, [3]USDA - Agricultural Research Service, Burns, OR

The increasing presence of wildfire on sagebrush landscapes is driving widespread loss of critical wildlife habitat and greatly diminished grazing resources. Over much of the

sagebrush region, these changes are associated with both the loss of sagebrush, as well as the increased post-fire presence of exotic annual grasses. These annual species increase fine fuel continuity and the probability of fire ignition and spread. Mature perennial bunchgrasses effectively compete with exotic annual grasses and can reduce spread and persistence of these species, but bunchgrasses are often killed by fire. Much of the effort to mitigate the exotic annual grass problem has centered on post-fire restoration of perennial bunchgrasses, however, post-fire seeding of perennial bunchgrasses often fails, particularly on warm and dry sites that are prone to annual grass invasion. Pre-fire fuels management may help to reduce both perennial bunchgrass mortality during the fire, and the need for restoration following fire. In recent field research, we have documented that perennial bunchgrass mortality in wildfire can be high (up to 60%) and that most bunchgrass mortality during wildfire is associated with close proximity to sagebrush fuels. Follow-up research has confirmed that sagebrush fuels produce very high heat output during combustion and that combustion of shrub fuels is the primary factor associated with generating heat loads high enough to kill perennial bunchgrasses. Heat output from grasses is comparatively low, and insufficient to cause perennial bunchgrass mortality. However, grass fuels serve as a vector to carry fire from shrub to shrub and reducing grass fuels can decrease shrub combustion and fire behavior measures. Overall, recent data suggest that preemptive manipulation of both shrub and grass fuels has the potential to reduce mortality of perennial bunchgrasses during fire, thus increasing post-fire resistance to annual grass invasion.

WHAT WE KNOW AND WHAT WE NEED TO KNOW ABOUT SAGEBRUSH RESTORATION. Amanda Gearhart*[1], Kirk W. Davies[2]; [1]USDA-Agricultural Research Service, Burns, OR, [2]USDA - Agricultural Research Service, Burns, OR

Big sagebrush (*Artemisia tridentata* Nutt.) steppe is one of the most imperiled ecosystems and covers vast areas in the western United States. We synthesized the literature on sagebrush restoration. Most literature focuses on Wyoming big sagebrush (*A. tridentata* Nutt. subsp. *wyomingensis* Beetle & Young) likely because it is slow to recover and Wyoming big sagebrush communities are one of the least resilient sagebrush communities. We characterized the current body of literature in terms of restoration methods and identified knowledge gaps where more information is needed to improve restoration. We found successful restoration of big sagebrush appears to vary considerably by subspecies. Many broadcast seedings of Wyoming big sagebrush failed to establish sagebrush plants whereas outplantings generally have some survival (34% average four years post planting). Many reports of successful shrub establishment, regardless of restoration method, note favorable precipitation. Controlling existing vegetation may also be important to reduce competition. Critical knowledge gaps include the relationship between climatic conditions (temperature and precipitation) and sagebrush establishment and survival; effects of seed locality and adaptability, seeding rate recommendations, and planting depths on seedling emergence and survival; and long term effects of restoration efforts and practices in arid ecosystems where change is often measured in decades. Given the high treatment costs and limited success in Wyoming big

sagebrush restoration, preservation of existing Wyoming big sagebrush communities should be a priority.

Oral Technical Session:
Riparian Ecosystems/Water

HYDROLOGIC CONNECTIVITY IN JUNIPER ENCROACHED RANGELANDS. Philip E. Caruso*[1], Carlos Ochoa[1], Tim Deboodt[2]; [1]Oregon State University, Corvallis, OR, [2]Oregon State University Extension, Prineville, OR

The expansion of juniper woodlands on rangelands across the western US has significantly altered existing landscapes. Regions that were historically sage steppe and grasslands have shifted to woodland ecosystems. This change has disrupted many important ecologic and hydrologic functions. Hydrologic connectivity, or, the way surface water and groundwater move through the watershed, is often poorly understood in these semi-arid regions. Knowledge of how surface water and groundwater are moving through the landscape is important for implementing both short and long term management strategies. This study focused on identifying hydrologic connections of two upland watersheds; one treated (juniper removed) and one untreated (juniper encroached) and the riparian valley they flow into. Our focus was primarily on the effects of juniper canopy interception, movement of water through the soil profile, and subsurface flow. Study results show canopy interception can be as high as 70%, impacting soil moisture and potential groundwater recharge. Additionally, results indicate increased soil moisture and shallow aquifer residence time in the treated watershed when compared to the heavily encroached untreated watershed. Shallow groundwater response is observed through a network of monitoring wells and springs located in each watershed. A delayed response is seen in wells located in the riparian valley compared to the watershed wells. This, along with isotope trace analysis, indicated a similar signature in both places, suggesting temporary subsurface hydrologic connections through the system.

SOIL AND WATER EXTERNALITIES STEMMING FROM WATERSHED- AND REGIONAL-SCALE LAND USE CHANGES. Benjamin Turner*[1], Jay Fuhrer[2], Melissa Wuellner[3], Hector Menendez[3], Barry Dunn[3], Roger Gates[4]; [1]Texas A&M University-Kingsville, Kingsvilee, TX, [2]National Resources Conservation Service, Bismarck, ND, [3]South Dakota State University, Brookings, SD, [4]South Dakota State University, Rapid City, SD

Recent central U.S. land use trends indicate large shifts from native or restored grasslands towards increased row crop cultivation. Research to-date indicates contemporary land use changes are complex, with multifaceted drivers and relationships across multiple scales. This research has also been used to promote ongoing soil health agendas employed by U.S. organizations. However, as the cultivated footprint continues to expand, concerns over soil erosion, watershed runoff volumes, and water quality have likewise escalated.

This is particularly true in the northern and western Great Plains, where soil and climate characteristics limit row crop productive potential. Watershed-level impacts of this type of land use change has been less studied than regional or farm level efforts. We identified multiple cases documenting soil and water externalities (i.e., unintended consequences of land use that adversely impacts other parties; e.g., soil erosion, watershed hydrological changes, and total suspended solids in streams) at watershed and landscape scales using a variety of data sources, including: USDA-NASS's Cropland Data Layer, watershed model generated data, NASA satellite imagery, state conservation agency databases, and local observations. In general, increases in these externalities occurred in counties with recent land use shifts away from grassland dominated landscapes to increased cultivated footprints since the mid-2000s. By documenting these cases, our project aims to promote the adoption of soil potential and soil risk (defined by local topographic and climate characteristics) into contemporary soil health initiatives, as this should aid in avoiding increased soil and water externalities while continuing to meet the growing societal needs from agriculture.

MANAGING UPLAND VEGETATION AS A MITIGATION STRATEGY FOR CLIMATE CHANGE EFFECTS ON PRAIRIE POTHOLE WETLANDS. Edward S. DeKeyser[1], David A. Renton*[1], David Mushet[2]; [1]North Dakota State University, Fargo, ND, [2]Northern Prairie Wildlife Research Center, Jamestown, ND

The landscape of the prairie pothole region contains a multitude of depressional wetlands known as prairie-pothole wetlands. These wetlands produce 50-80% of North America's waterfowl populations. Waterfowl populations in the region respond to changes in water level caused by a dynamic climate that includes periods of drought and deluge. Prairie-pothole wetland water budgets are largely dependent on atmospheric interactions. The hydroperiod and extent of ponded water in prairie-pothole wetlands decrease during extended drought and increase during deluge conditions. Previous modeling of prairie-pothole wetlands has suggested that climate change may cause significant decreases to hydroperiods and ponded-water area. Thus, waterfowl populations are expected to suffer under a changed climate. Upland range management techniques, such as grazing and burning, may present a tool to ameliorate the effects of a warmer climate on these wetlands. We experimentally investigated the effects of upland vegetation management on the hydrology of prairie-pothole wetlands, specifically winter snow distributions as snowmelt is the major input of water for these wetlands. We also used a wetland simulation model to quantify changes in wetland water levels that would be required to mitigate for increased atmospheric losses resulting from a warmed climate. Results from the wetland simulation model suggest that increased temperatures will have a significant impact on wetland hydrology. On average, a 2 °C temperature increase caused the simulated wetland to dry 16.7 days sooner. Water inputs would need to increase by 33.2% to fully mitigate increased water losses. Applied managements of grazing and fall burning failed to increase water inputs in terms of snowmelt into the studied wetlands. Thus, it is unlikely that changes in upland management will be able to fully mitigate the effects of a warming climate in rangeland areas of the Prairie Pothole Region.

PLANT COMMUNITY INFLUENCES ON INTERMITTENT STREAM STABILITY.

Garret A. Hecker*[1], Miranda A. Meehan[1], Jack Norland[1], Jeffrey L. Printz[2]; [1]North Dakota State University, Fargo, ND, [2]USDA-NRCS (Retired), Lisbon, ND

The composition of the greenline plant community is linked to the stability of riparian ecosystems. Cool season exotic upland grasses are invading native plant communities across the northern Great Plains, potentially compromising streambank stability and increasing the risk of erosion within riparian ecosystems. To determine how the species composition of the greenline community impacts stream type and the risk of streambank erosion, thirty five reaches across five watersheds were sampled to determine the dominant greenline vegetation. At each reach sampled, a cross-section was conducted to determine the stream type, greenline vegetation, and the risk of streambank erosion. The stream types were delineated using Rosgen's classification of natural rivers methods that separates reaches based on the parameters of entrenchment ratio, width to depth ratio, sinuosity, slope, and dominant channel materials (Rosgen 1994). Canopy cover and composition was assessed using the line point intercept method along a 100 ft. transect in the greenline community. The Bank Erosion Hazard Index (BEHI) was used to assess the streams risk of erosion by calculating the difference between the bank height and bank full height, average plant rooting depth and density, bank angle degree, and the dominant texture of the bank material. A Nonmetric Multidimensional Scaling ordination was performed to analyze the data. Analysis of the data determined that the most stable stream types (E and C channels) and lower BEHI scores were associated with high amounts of litter and facultative wet species. In comparison, unstable F channels were associated with early successional species and bare ground. Sites with the higher BEHI scores were influenced by upland and facultative upland species and saline soils. Late successional facultative wetland species therefore offer the most protection to intermittent stream banks.

STREAM TEMPERATURE DYNAMICS IN A SEMIARID RIPARIAN ECOSYSTEM IN NORTH CENTRAL OREGON. Carlos G. Ochoa*, Eashan Shahriary; Oregon State University, Corvallis, OR

We evaluated changes in stream temperature dynamics as affected by vegetation structure, streamflow, and stream-aquifer interactions in a 1-km reach of a semiarid riparian corridor in north central Oregon. We determined vegetation structure and estimated canopy cover along the riparian area. We installed multiple stream, groundwater, and ambient temperature sensors at selected locations along the reach. Stream temperature sensors were installed at shaded and exposed locations. In the summer of 2014, we used Distributed Temperature Sensing (DTS) and fiber optic technology to accurately measure stream water temperature at fine temporal (every 15 min) and spatial (every one meter) resolution scales. DTS data findings were compared to data obtained from point specific temperature sensors (17) installed in the creek. Preliminary results show Gray Alder (*Alnus incana*) and Reed Canary Grass (*Phalaris*

arundinacea) were the dominant overstory and understory species. No significant changes in stream temperature were observed in shaded versus exposed sensor locations. Greater stream temperature levels were observed between 3 and 5 pm in most days and stream temperature fluctuations followed those from ambient temperature. A close agreement between stand-alone sensor and DTS stream temperature measurements was observed. The finer spatial resolution of the fiber optic cable measurements allowed for a better understanding of vegetation-stream temperature dynamics. Surface and subsurface flow contributions from a tributary meeting the creek resulted in minor changes in stream temperature conditions at the confluence.

IMPROVING MODELING OF GROUNDWATER CONTAMINATION MOVEMENT IN TOOELE VALLEY. Linden K. Greenhalgh*[1], Jon P. Fenske[2]; [1]Utah State University, Tooele, UT, [2]Corps of Engineers, Davis, CA

Trichloroethylene (TCE) contamination in groundwater from cleaning army equipment is moving downgradient through the Tooele Valley. From 1942 to 1966, various hazardous wastes produced by Tooele Army Depot were disposed in wastewater which flowed through unlined ditches to spreading areas and unlined lagoons.
After several phases of environmental assessment and remedial field investigations the ditches and lagoons were closed. Monitoring wells were established and a pump and treat system were put in place to reduce contaminant concentrations.
Ongoing testing monitors TCE levels and movement (referred to as the plume). Currently, approximately 146 wells are sampled semi-annually. Two plume lobes are apparent. The wide plume lobe originating at the ditches called the main plume and a narrow concentrated plume lobe called the Northeast Boundary plume.
No irrigation or culinary wells currently draw water out of the plume area. However, it appears that wells down-gradient and nearby ponds affect groundwater movement and aquifer recharge. Modeling technology is used to predict plume movement and contamination concentration through space and time. Recent on-site investigation has revealed information that has improved the prediction model.

Oral Technical Session:
Remote Sensing and Technology

MAPPING CANADA'S RANGELAND AND FORAGE RESOURCES USING EARTH OBSERVATION. Emily Lindsay[1], Andrew Davidson[2], Doug King[1], Bill Houston*[3]; [1]Carleton University, Ottawa, ON, [2]Agriculture and Agri-Food Canada, Ottawa, ON, [3]Agriculture and Agri-Food Canada, Regina, SK

Rangeland occupies over half of the earth's land surface by some estimates (51% - according to the World Resources Institute, 1986). Canada is the second largest country in the world covering approximately 10 million km2. How much of Canada is covered by rangeland and forages? That is the question that prompted this project by Agriculture

and Agri-Food Canada (AAFC). AAFC has produced an Annual Crop Inventory map product since 2009 that shows the types of crops grown in Canada each year, including an estimate of the area of rangeland and forages. AAFC hired Emily Lindsay, an MSc Candidate at Carleton University, to determine which variables derived from remote sensing and geospatial data can be most effectively used to produce increased classification accuracy of Canada's rangeland and forage resources. Field data related to land cover type and dominant species composition were collected during the 2015 growing season at study sites west of Brandon, Manitoba and near Lethbridge, Alberta. Multispectral imagery at two scales (RapidEye and Landsat-8) and Radarsat-2 imagery are being integrated into Random Forest classifications to determine variable importance, to aid in selection of appropriate variables for classification and to analyze the spatial distribution of classification quality for rangeland and seeded forage classes. Variables include standard multispectral reflectance as well as vegetation phenology and radar variables. Results will create a robust set of methods to support a future operational inventory of rangeland and forage resources to complement AAFC Annual Crop Inventory.

INTEGRATING GEOSPATIAL TECHNOLOGIES TO MONITOR AND MANAGE INVADER SPECIES IN RANGELANDS. Humberto L. Perotto*[1], Chase Walther[1], Karelys N. Labrador-Rodriguez[1], Jose M. Mata[2], J. Alfonso Ortega-S.[1], Sandra Rideout-Hanzak[1], David B. Wester[1], Jinha Jung[3], Anjin Chang[3], Junho Yeom[3]; [1]Texas A&M University - Kingsville, Kingsville, TX, [2]Texas A&M University-Kingsville, Kingsville, TX, [3]Texas A&M University Corpus Christi, Corpus Christi, TX

The explosion of geospatial technologies is providing new opportunities to explore and study rangelands at spatial and temporal scales that were not possible a few years ago. One area where these technologies are playing a fundamental role is in the monitoring of invader species and how they can potentially affect the distribution of cattle in pastures. The objective of this presentation is to provide a summary of multiple projects aimed at one common goal: the control of an invader species through management. We are integrating habitat management, fire ecology, and landscape ecology with geospatial technologies to better understand the effects of different management strategies to minimize the impact of tanglehead in South Texas pastures. Prescribed fires are used to remove above-ground biomass and decadent growth creating palatable growth that can be consumed by cattle. Cattle are being used as a management tool, and are fitted with GPS collars (10-minute interval between locations) to assess their movement and habitat use. Unmanned aerial systems are being used to map prescribed burned areas and to quantify the changes in species and aboveground biomass resulting from the fire and pasture use by cattle. We are also using remote sensing to classify the spatial distribution of vegetation types and their temporal dynamics. All data and information are collected and integrated in a geographic information system and that are analyzed to generate new information on the spatial and temporal dynamics of tanglehead and its potential impact on pasture use by cattle.

ADDRESSING SAGE-GROUSE HABITAT PROGRAMS USING REMOTELY SENSED INFORMATION. Eric D. Sant*[1], Gregg E. Simonds[1], Brenda Younkin[2]; [1]Open Range Consulting, Park City, UT, [2]Y2 Consultants, Jackson Hole, WY

With the status of Sage-grouse there are a multitude of programs spanning federal, state, and local government agencies. These programs include regulatory, and mitigation type activities. Each of these programs has merit in its aim to protect and enhance Sage-grouse habitat and ultimately the bird. Because these programs impact mineral extraction, infrastructure construction, and livestock grazing there is a need to assess habitat in a cost effective, timely, and accurate manner that reflect the entire landscape. Limited budgets and personnel make assessing and monitoring the Sage-grouse resources very difficult. Stand-alone ground based assessment and monitoring protocols are often expensive, infrequent, and not representative of the actual condition and trend. Consequently, valuable field time is spent in collecting data that does not reflect actual conditions wasting valuable time and public money. Range professionals are highly trained and competent at their jobs but are hamstrung by inadequate tools and the sheer size of the lands they manage. Their judgment and experience needs to be leveraged by their tools instead of limited. Remotely sensed data is the tool that can accomplish this. Additionally, the limitations of new staff and agency turnover on long term monitoring efforts can also be overcome by having a standardized data set showing long term trend. We would like to demonstrate the potential of remotely sensed data used by range professionals to augment current data and long term needs posed by Sage-grouse programs.

DEVELOPING A MODEL THAT PREDICTS THE DISTRIBUTION OF MEDUSAHEAD USING REMOTE SENSING TECHNIQUES. Timothy M. Bateman*; Utah State University, Logan, UT

Medusahead (*Taeniatherum caput-medusae* [L.] Nevski) is an invasive annual grass that alters whole ecosystems, reducing rangeland productivity in the western United States. The ability of this weed to rapidly spread and outcompete native vegetation is a call of concern for landowners and land managers. To aid in control efforts, managers would benefit through a better understanding of its underlining invasive processes as well as from an enhanced ability to detect invasion sites across broad landscapes. Remote sensing has been recognized as a valuable tool in monitoring and assessing large extents of rangelands. Thus, the successful delineation of medusahead using aerial imagery would prove to be advantageous for managers in directing control efforts. Beginning in the fall of 2015 steps have been made into developing methods to identify and predict medusahead distribution in a 57,000-ha study area in the Channeled Scablands of Eastern Washington using remote sensing techniques. Using a multi-scale approach, coarser predictor variables were used to model high resolution fractional cover (fCover) derived from a classification. Research has been successful ($R2=0.82$) in developing a model that predicts continuous fCover of medusahead from Landsat (30m resolution) imagery. Using the high temporal resolution of Landsat imagery, efforts are being made into achieving historical trend data of medusahead invasion in the area. This research is

innovative and offers advancements for better understanding the characteristics of medusahead invasion in the region. Results from this research can aid in the development of novel management approaches leading to more adaptable and sustainable production in rangelands challenged by medusahead invasion.

MAPPING TREE CANOPY COVER IN SUPPORT OF PROACTIVE PRAIRIE GROUSE CONSERVATION IN WESTERN NORTH AMERICA. Michael J. Falkowski*[1], Jeffrey Evans[2], David Naugle[3], Christian Hagen[4], Scott A. Carleton[5], Brady Allred[3], Jeremy D. Maestas[6], Andrew Lawrence[7]; [1]Colorado State University, Fort Collins, CO, [2]The Nature Conservancy, Fort Collins, CO, [3]University of Montana, Missoula, MT, [4]OSU, Bend, OR, [5]United States Geological Survey, Las Cruces, NM, [6]USDA-NRCS, Redmond, OR, [7]New Mexico State University, Las Cruces, NM

Invasive woody plant expansion is a primary threat driving fragmentation and loss of sagebrush (*Artemisia* spp.) and prairie habitats across the central and western United States. Expansion of native woody plants, including conifer (primarily *Juniperus* spp.) and mesquite (*Prosopis* spp.), over the past century is primarily attributable to wildfire suppression, historic periods of intensive livestock grazing, and changes in climate. To guide successful conservation programs aimed at reducing top-down stressors, we mapped invasive woody plants at regional scales to evaluate landscape level impacts, target restoration actions, and monitor restoration outcomes. Our overarching goal was to produce seamless regional products across sociopolitical boundaries with resolution fine enough to depict the spatial extent and degree of woody plant invasion relevant to greater sage-grouse *(Centrocercus urophasianus)* and lesser prairie-chicken *(Tympanuchus pallidicinctus)* conservation efforts. We mapped tree canopy cover at 1-m spatial resolution across an 11-state region (508,265 km2). Greater than 90% of occupied lesser prairie-chicken habitat was largely treeless for conifers (< 1% canopy cover), whereas > 67% was treeless for mesquite. Conifers in the higher canopy cover classes (16−50% and > 50% canopy cover) were scarce (<2% and 1% canopy cover), as was mesquite (< 5% and 1% canopy cover). Occupied habitat by sage-grouse was more variable but also had a relatively large proportion of treeless areas. Low to moderate levels of conifer cover (1−20%) were fewer as were areas in the highest cover class (>50%). Mapping indicated that a high proportion of invading woody plants are at a low to intermediate level. Canopy cover maps for conifer and mesquite resulting from this study provide the first and most geographically complete, high-resolution assessment of woody plant cover as a top-down threat to western sage-steppe and prairie ecosystems.

DISTURBANCE AUTOMATED REFERENCE TOOLSET (DART): ASSESSING ECOLOGICAL RECOVERY FROM ENERGY DEVELOPMENT ON THE COLORADO PLATEAU. Travis W. Nauman*[1], Michael C. Duniway[2], Miguel L. Villarreal[3], Travis B. Poitras[3]; [1]USGS, Moab, UT, [2]US Geological Survey, Moab, UT, [3]U.S. Geological Survey, Menlo Park, CA

A new disturbance automated reference toolset (DART) was developed to monitor human land surface impacts using soil-type and ecological context. DART identifies reference areas with similar soils, topography, and geology; and, based on a satellite vegetation index, compares the disturbance condition to the reference area condition using a quantile-based approach. DART was able to represent 26-55% of variation of relative differences in bare ground and 26-41% of variation in total foliar cover when comparing sites with nearby ecological reference areas using the Soil Adjusted Total Vegetation Index (SATVI). Assessment of ecological recovery at oil and gas pads on the Colorado Plateau revealed that more than half of well-pads were below the 25th percentile of reference areas particularly in grasslands, blackbrush (*Coleogyne ramosissima*) shrublands, arid canyon complexes, warmer areas with more summer-dominated precipitation, and state administered areas. Results showcase the usefulness of DART for assessing discrete surface land disturbances, and highlight the need for more targeted rehabilitation efforts at oil and gas well-pads in the arid southwest US.

DETECTABILITY OF OLD WORLD BLUESTEM USING REMOTE SENSING APPLICATIONS. Lori E. Brown*, Robert Cox; Texas Tech University, Lubbock, TX

Non-native species invasion is a recognized threat to grassland ecosystems. Invasive species can alter plant community composition, decrease biological diversity, change nutrient cycling and affect disturbance regimes. Old world bluestem (*Bothriochloa ischaemum*), not native to North America, can have negative impacts on native plant communities and is successful in establishing near-monoculture stands. Although common throughout central Texas, little is known about its full distribution. Our study aim was to examine the applicability of using remote sensing technology to detect stands of Old World Bluestem. We attempted to use phenological variation to distinguish the presence or absence of Old World Bluestem. The study examined sites located in the Southern High Plains ecoregion, which encompasses areas of northwest Texas and eastern New Mexico. This was conducted by examining sites representing a remnant shortgrass prairie system, dominated by blue grama (*Bouteloua gracilis*) and comparing those sites to areas of known Old World Bluestem occurrence. Landsat TM and ETM+ imagery was acquired for growing season months (roughly April through October) and NDVI values were calculated to determine start of season green up, peak greenness and fall senescence. Phenological and interannual variability between blue grama and Old World Bluestem sites might be useful for identifying possible invasion fronts.

USE OF HIGH RESOLUTION SATELLITE IMAGERY TO CLASSIFY NORTHERN GREAT PLAINS PLANT COMMUNITIES. Jameson R. Brennan*, Patricia M. Johnson, Kenneth C. Olson, Niall P. Hanan; South Dakota State University, Rapid City, SD

Remote sensing provides researchers the ability to study and assess landscape level changes in plant communities over broad spatial and temporal scales. The use of high resolution imagery often improves capacity to capture patch level changes in structure

and community transitions that may be lost at coarser scales. Ability to identify plant community differences and changes in phenology over a growing season can greatly aid in understanding how vegetation dynamics influence livestock grazing behavior. Few studies have evaluated the use of high resolution satellite imagery to identify and map distinct plant communities within the Northern Great Plains, and track phenological changes associated with plant communities through time. A study was conducted in north-central South Dakota to remotely sense five plant communities located both on and off prairie dog towns in the Northern Great Plains. These included forb and grass dominated sites on-town, warm- and cool-season grass dominated sites off-town, and snowberry patches off-town. During 2015 and 2016, Pleiades satellites were tasked to image the study site for a total of five monthly images each summer from June to October to coincide with livestock grazing at the site. Imagery was converted into a normalized difference vegetation index (NDVI). Training sites were mapped for each plant community of interest, and all spectral bands extracted to our training sites were used to construct a random forest algorithm to facilitate classification of plant communities. Plant community phenology was tracked using NDVI time series values and analyzed for differences between plant communities, months, and years. Results from this study will help researchers 1) determine optimal timing to collect satellite imagery based on plant community of interest, and 2) build thematic maps that can be overlain with livestock grazing behavior to better understand grazing selection.

NOVEL TECHNOLOGY FOR MEASURING ANIMAL MOVEMENT ON RANGELANDS. Tamarah R. Plechaty*[1], Derek Scasta[1], Justin D. Derner[2], David J. Augustine[3]; [1]University of Wyoming, Laramie, WY, [2]USDA-ARS, Cheyenne, WY, [3]USDA-ARS, Fort Collins, CO

Previous comparisons of animal responses to grazing management have largely focused on animal weight gains. As a result, we have an incomplete understanding of the effects of grazing management on attributes such as animal movement. Moreover, the influence of animal movement, such as the distance traveled by livestock, could provide insights into processes involved with grazing behavior and associated animal energetics and expenditures. Here we used novel technology of IceTag pedometers (IceRobotics Ltd, South Queensferry, UK) to record number of steps, lying time, standing time, and motion indices of individual animals with contrasting grazing management: 1) season-long grazing, mid-May through early October, in 10 replicate 130 ha pastures with stocking density of 0.18 steers ha-1, and 2) pulse grazing (short grazing periods with single large herd rotating among 10 paired, 130ha pastures with ten-fold greater stocking density of yearling steers (1.8 steers ha-1). Both grazing treatments had a moderate stocking rate (0.6 AUM ha-1). The study was conducted in 2015 and 2016 at the USDA-ARS Central Plains Experimental Range, a Long-Term Agro-ecosystem Research (LTAR) network site. Two steers in each of the season-long grazing pastures and 10 of the 234 steers in the pulse grazing treatment were randomly chosen to be fitted with pedometers. For the 2015 grazing season, yearlings in the pulse grazing treatment took more steps and had a higher motion index, with less lying time compared to steers in the season-long grazing

treatment. Differential animal movements between grazing treatments were largely driven by differences observed when grazing occurred in pastures dominated by Sandy Plains ecological sites as no differences were present when grazing pastures dominated by Loamy Plains ecological sites. Animal movement differences between grazing treatments provide insight into the processes associated with observed lower individual animal weight gains of steers with the pulse grazing.

FACTORS INFLUENCING THE SPATIAL AND TEMPORAL DISTRIBUTION OF TANGLEHEAD (*HETEROPOGON CONTORTUS*) ON SOUTH TEXAS RANGELANDS. Jose M. Mata*[1], Humberto L. Perotto[2], Fidel Hernandez[3], Eric D. Grahmann[1], Sandra Rideout-Hanzak[1], Jaclyn Robles[4], Michael T. Page[1]; [1]Texas A&M University-Kingsville, Kingsville, TX, [2]Texas A&M University - Kingsville, Kingsville, TX, [3]Caesar Kleberg Wildlife Research Institute, Kingsville,

Tanglehead (*Heteropogon contortus*) is a perennial grass native to Southwestern US rangelands; however, its prevalence as an invasive on South Texas rangelands has grown. In the last decade, large monotypic stands of tanglehead have emerged, simplifying native vegetative communities in Jim Hogg, Brooks and Kleberg Counties. The dominance of this species in sandy soils is a cause for concern for many ranchers as it may have negative impacts on wildlife resources. Unfortunately, little is known regarding the spatial extent of this invasion and its impact. The goal of this project is to determine the extent and spatial distribution of tanglehead in Jim Hogg and Duval Counties using freely available remote sensing platforms. The specific objectives are: (1) to determine the feasibility of classifying tanglehead from other vegetation types using National Agriculture Imagery Program (NAIP) aerial imagery and (2) to quantify the spatial and temporal distribution of tanglehead in critical areas identified by ranchers in South Texas. To achieve this goal, 22 color-infrared 1–meter resolution NAIP imagery (2014) were classified by combining the NAIP bands (red, green, blue, near infrared) with the normalized difference vegetation index (NDVI) to identify tanglehead from other land cover types (woody, non-tanglehead herbaceous, and bare soil) and assess its spatial distribution. The accuracy of the classified imagery was assessed using a confusion matrix. The overall accuracy exceeded the minimum national standard of 85%. This process was repeated for imagery available in 2008, 2010, and 2012. The changes observed in the spatial distribution of tanglehead between years will be compared and assessed. Accuracy assessments are currently being conducted for the 2008 – 2012 imagery and impacts of roads and soils in the distribution of tanglehead will be evaluated as well.

Symposium:
Remote Sensing and Spatial Modelling in Support of Public Land Management and Administration

CHARACTERIZING AND MONITORING WESTERN SHRUB AND GRASSLANDS WITH REMOTE SENSING, MANAGEMENT UTILITY AND APPLICATION. Collin Homer*; USGS, Boise, ID

Accurate and consistent characterization of shrub and grassland components and how they change across time is crucial to understanding and managing these ecosystems. The USGS and BLM have been working together to provide new remote-sensing products that characterize Western shrub and grasslands by their fractional proportions of shrub, sagebrush, herbaceous, bare ground and other targets. These component products offer maximum flexibility to develop a variety of applications at ecosystem scales that can then be monitored for change across time. Additionally, by using the Landsat archive of imagery since 1984, historical trends can be developed to help understand future land change trajectories. This presentation will overview these new remote sensing products that are being generated across the west, and outline their potential utility for management applications in climate change, wildlife habitat, restoration and other areas.

MODELING AND DECISION SUPPORT FOR RIPARIAN AREA MANAGEMENT. Linda A. Spencer*[1], Sinan A. Abood[2]; [1]Forest Service, Washington, DC, [2]Forest Service ORISE Fellow, Washington, DC

Riparian areas have high biodiversity and contribute important habitat for plants and animals. Riparian areas are a very small percentage (<1%) of the Forest Service landscape, yet these areas provide numerous ecosystem services including contributions toward clean water. Geology, landscape, soils and vegetation are controls of riparian area responses to land management activities and uses, and responses to climate related events. The first step to studying these systems is to create a base map that is accurate and consistent across the landscape. Two national Forest Service staff areas have collaborated on a project to map all riparian areas, assess riparian areas within rangelands, and to create a tool to assist the field with focusing management. A unique approach to mapping, using ArcGIS and freely available information, provides the base map. Ancillary data, such as land cover type, tree canopy and land use are investigated in these areas and within the surrounding landscape analysis units. Potential uses for the model, map and information include prioritizing landscape or smaller scale restoration needs, supporting Forest planning processes and allotment management plans, assessing change, and improving our understanding of riparian area responses to land management.

CHEATGRASS MAPS TO INFORM LAND MANAGEMENT DECISIONS. Bruce K. Wylie*[1], Stephen P. Boyte[2], Donald J. Major[3]; [1]USGS EROS, Sioux Falls, SD, [2]2Stinger Ghaffarian Technologies, Inc. Contractor to the U.S. Geological Survey EROS Center, Sioux Falls, SD, [3]BLM, Idaho State Office, Boise, ID

We developed a time series (2000 – 2014) of 250-meter cheatgrass (*Bromus tectorum*) percent cover maps and datasets in the Northern Great Basin, USA. We used remote

sensing data integrated with geophysical data into regression-tree models to develop the maps and data. Additionally, we produced near-real-time cheatgrass percent cover maps and datasets for 2015 and 2016. These near-real-time maps and data were completed and ready for distribution by early July of their respective years (download maps and data at: https://nccwsc.usgs.gov/display-project/4f8c64d2e4b0546c0c397b46/5006f498e4b0abf7ce733f92). Land managers can use the maps to track changing cheatgrass dynamics (e.g., cheatgrass dieoff) and to identify areas that could be susceptible to cheatgrass expansion under future climate regimes, (e.g., greater sage grouse priority areas for conservation).

Responding to user requests, we developed plans to greatly expand the study area and to release multiple near-real-time cheatgrass maps and datasets starting earlier in the year. The study area size increased from about 505,000 km2 to approximately 1.325 million km2, an increase of more than 2.5 times. All of Wyoming and parts of 10 other states are included in the study area, with the southern boundary extended to encompass the entire Great Basin ecoregion. To accommodate fire modelers, we are working to release a near-real-time cheatgrass percent cover map and dataset during May 2017. This May release will be followed by June and July releases that will include updated satellite vegetation information that should increase mapping accuracy.

SIMULATION MODELING TO ANSWER INVASIVE SPECIES MANAGEMENT QUESTIONS. Catherine Jarnevich*[1], Catherine Cullinane Thomas[2], Nicholas Young[3], Leonardo Frid[4]; [1]Fort Collins Science Center, Fort Collins, CO, [2]U.S. Geological Survey, Fort Collins, CO, [3]Colorado State Unviersity, Fort Collins, CO, [4]Apex Resource Management Solutions LTD, Ottawa, ON

Invasive species are one change agent that can impact natural areas and can interact with other ecosystem modifiers such as climate change and fire. State-and-transition simulation models (STSMs) can provide information to resource managers about potential outcomes of management actions in the face of multiple, interacting change agents. These models divide the landscape into various states (such as uninvaded, low invasion, moderate invasion, high invasion) and simulate changes in states through time based on transitions that can be natural processes (such as growth and spread) or management actions (such as control). One of the major strengths of this tool is the ability to simulate and evaluate various 'what if' scenarios. For example, a no management action scenario can provide information on how big a problem is while an unlimited management scenario can provide information on how much effort would be required to achieve long-term suppression. Scenarios can be explored to determine efficient combinations of management practices, both economically and ecologically, and to determine potential impacts of climate change and invasion effects on fire regimes. We will present an example of these types of 'what if' scenarios for buffelgrass (*Cenchrus ciliaris*) invasion in Saguaro National Park, Arizona, taking into account potential effects of climate change and buffelgrass alteration of the fire regime.

USING TIME SERIES LANDSAT IMAGERY AND HISTORIC CLIMATE DATA TO INFORM RANGE MANAGEMENT PLANNING. Steve Brown*; USDA Forest Service, Missoula, MT

This project uses the Landsat Time Series data available in Google Earth Engine along with a site moisture suitability index to characterize rangeland productivity in Southwest Montana. These data combined with climate records are used to estimate changes in range condition and carrying capacity based on average, dry, and wet years. This process can be used to predict range condition based on Spring climate so that managers and permittees can plan accordingly for the year. This data will also be useful for helping to inform range managers that are new to areas and lack the long term experience with conditions and climate.

CLIMATE PIVOT POINTS: A NEW TOOL TO IDENTIFY CHANGES IN RANGELAND PRODUCTIVITY. David Thoma*[1], Seth Munson[2], Dana Witwicki[3]; [1]National Park Service, Bozeman, MT, [2]U.S. Geological Survey, Flagstaff, AZ, [3]National Park Service, Moab, UT

Rangeland managers in the western U.S. need information to help plan for shifts in plant production that will accompany a potentially warmer, drier and more variable climate. Climate pivot points are a promising new method to identify production responses to climate conditions and define when production shifts from below to above average. In addition to determining critical water needs of vegetation, the pivot point framework provides information on drought resistance. We apply the concept of climate pivot points to the landscape level using high temporal frequency remote sensing observations of the Normalized Difference Vegetation Index (NDVI), a proxy for plant production. We characterize climate conditions using a water balance model that integrates climate and site factors that moderate climate. We stratify the landscape to vegetation map units to define pivot points, drought resistance, and response in grasslands, blackbrush, and sagebrush shrublands. We found differences in plant responses and drought resistance related to vegetation type and soil properties. Our findings can be used to track the dynamics of vegetation condition at landscape scales within the growing season and as an early warning sign of undesirable vegetation state changes.

ESTIMATION OF SHRUB HEIGHT USING HIGH-RESOLUTION ORTHO IMAGERY AND PHOTOGRAMMETRICALLY DERIVED POINT CLOUDS. R. Douglas Ramsey*, Christopher McGinty, Thomas Thompson, Kristin Hulvey, Eric T. Thacker; Utah State University, Logan, UT

Digital photogrammetric surface models generated from low flying remotely piloted aircraft provide a wealth of data that can be used to interpret surface features at centimeter to sub-centimeter spatial resolutions. Digital terrain models at this high spatial resolution when applied to the study of vegetation communities can provide detailed information of vegetation structure, height, cover, and density that heretofore

could only be acquired using expensive and time-consuming field surveys. Further, unlike field surveys, these data, coupled with matching color ortho-imagery, provide a highly detailed, permanent record of vegetation community conditions that can be revisited and re-analyzed in the future. This ability to re-analyze original data and extract additional or improved information as statistical and spatial analysis techniques mature promises to revolutionize the monitoring of natural landscapes. This study shows that high resolution, natural-color imagery collected with a remotely piloted aircraft and processed to extract a topographic point-cloud is very effective at estimating individual shrub height and cover as well as producing a high quality spatial database consisting of an ortho-image coupled with a detailed photogrammetric point-cloud. The combination of these two datasets provides an excellent tool for characterizing shrub communities at a level of detail that will allow land managers to effectively assess canopy cover, height, structure, and potentially help characterize erosional features such as gully development and pedestaling.

QUANTIFYING FORAGE PRODUCTION AND RANGELAND CARBON TO ASSIST FOREST SERVICE PLAN REVISION AND NEPA ASSESSMENT. Matt C. Reeves*; USDA Forest Service, Florence, MT

The Rangeland Vegetation Simulator (RVS) was applied to the Pacific Southwest (Region 5) and Intermountain West (Region 4) regions of the U.S. Forest Service to aid in NEPA analysis and Forest Plan Revision. In Region 5, grazing allotments are monitored to ensure that best management practices are applied, standards and guidelines are met, and landscapes are meeting or moving towards desired conditions. The Forest Service is required to develop and adhere to an analysis schedule for all of its grazing allotments. However, achieving analysis targets can be impeded for numerous reasons including competing priorities, issue complexity, appeals & litigation, budget direction, and cost. As a result we sought to aid the monitoring and assessment requirements by quantifying production trends across Region 5 grazing allotments and meadows and identify trends that might require further assessment to ensure that best management practices are applied. We applied subroutines of the Rangeland Vegetation Simulator (RVS) to analyze trends in rangeland production and develop indicators of possible vegetation underperformance across all allotments under NFS jurisdiction. This analysis reveals significant downtrends in production on some allotments enabling prioritization of ground reconnaissance. In Region 4, and in other regions, Forest Plan Revisions are underway. The 2012 Forest Planning Rule requires an assessment of carbon stocks. With Forested lands, the Forest Inventory and Analysis (FIA) Program can be used to estimate carbon stocks but despite the significant need, no equivalent comprehensive, and repeatable sampling program exists for non-forest lands under USFS jurisdiction. As a result, we assisted Region 4 by estimating above and below carbon stocks using the RVS for estimating above ground carbon stocks, and geospatial modeling guided by the Soil Survey Geographic Database (SSURGO) database.

Oral Technical Session:
Rangeland Social Science

EVALUATING SUPPORT FOR RANGELAND RESTORATION PRACTICES BY RURAL SOMALIS IN EASTERN KENYA. A Hussein Ali*[1], Jacob R. Goheen[2]; [1]affiliation, City, AL, [2]University of Wyoming, Laramie, WY

In developing countries, governments lack the authority and resources to implement conservation outside of protected areas. In such situations, the integration of conservation with local livelihoods is crucial to species recovery and reintroduction efforts. The hirola (*Beatragus hunteri*) is the world's most endangered antelope, with a population of <500 individuals that is restricted to <5% of its historical geographic range on the Kenya-Somali border. Long-term hirola declines have been attributed to disease and rangeland degradation. Tree encroachment is at least partly responsible for habitat loss and the decline of contemporary populations. Through interviews in local communities across the hirola's current range, we identified socially-acceptable strategies for habitat restoration and hirola recovery. We used classification and regression trees, conditional inference trees, and generalized linear models to identify social-demographic predictors of support for range-restoration strategies. Locals supported efforts to conserve elephants, seed and fertilize grass, and remove trees, but were opposed to livestock reduction. Locals were ambivalent toward controlled burns and soil ripping. Livestock ownership and years of residency were key predictors of locals' perceptions toward rangeland-restoration practices. Locals owning few livestock were more supportive of elephant conservation and seeding and fertilization of grass, while longer-term residents were more supportive of livestock reduction but were less supportive of elephant conservation. Ultimately, wildlife conservation outside protected areas requires long-term, community-based efforts that are compatible with human livelihoods. We recommend elephant conservation, grass seeding, manual tree removal, and resting range from livestock both to enhance the potential for hirola recovery and to build positive rapport with local communities in the geographic range of this critically-endangered species.

ADAPTIVE RANGELAND DECISION-MAKING AND COPING WITH DROUGHT. Leslie Roche*; University of California, Davis, Davis, CA

Grazinglands support the livelihoods of millions of people around the world, as well as supply critical ecosystem services. Communities reliant on rain-fed rangelands are potentially the most vulnerable to increasing climate variability given their dependence on highly climate-sensitive resources. Droughts, which are gradual natural hazards, pose substantial and recurrent economic and ecological stresses to these systems. This study examined management decision-making based on survey responses of 479 California ranchers to 1) identify the types of drought strategies in-place across California's

rangelands and the operation variables driving strategy selection; and 2) examine how individual drought adaptation is enhanced by decision-making factors. Four types of in-place drought strategies were identified and ordered along a gradient of increasing intensity (number) of practices used. Significant background variables driving strategy section were operation experience with drought, type of livestock operation, grazing system, and land ownership types. Information resource networks, goal setting for sustainable natural resources, and management capacity all acted to enhance individual drought adaptation—defined here by active drought planning and the number of both reactive and proactive drought practices used. Overall, analyses revealed that flexibility in management is a key component of adapting to and coping with drought. Climate policy planning should take into account the diversity of strategies that have been developed by ranchers for multiple generations and within the context of their unique operations, as well as support these working landscapes via a range of adaptation and mitigation options to reduce vulnerability across all types of operations.

THE ROLE OF IDAHO'S PUBLIC OPINIONS IN RANGELANDS ISSUES . Jeffry D. Wulfhorst*[1], Gretchen Hyde[2], K. S. Jensen[3], Neil Rimbey[4]; [1]University of Idaho, Moscow, ID, [2]Idaho Rangeland Resource Commission, Emmett, ID, [3]University of Idaho, Marsing, ID, [4]University of Idaho, Caldwell, ID

The Idaho Rangeland Resource Commission (IRRC) sponsored their first public opinion poll in 1997. The goal was to gain insight to the thoughts and preferences of Idahoans dealing with several rangeland issues. Over time, the survey results assist in setting priorities and identifying target audiences for public relations campaigns. The most recent survey report, completed in 2014, shows the highest level of support for grazing on public land – a contested practice by interest groups seeking to eliminate public lands grazing. In other measures, general public perspectives about species conservation and recreational impacts suggest the need for greater attention to insights from the general public – a stakeholder not always associated with rangelands management. In a series of surveys conducted within the state of Idaho over the last 20 years, we analyze the longitudinal and cumulative effects of what can be understood and gained from this type and scale of social science effort.   The presentation also outlines education and outreach components related to ongoing collaborations and partnership efforts within the state of Idaho that have accessed these results to forge alliances and be creative with solutions to maintain working landscapes. Data for the presentation were collected by a cohesive group of individuals collaborating across the state's unique Commission (IRRC) and the land-grant University's social science laboratory – the Social Science Research Unit (SSRU) – as a coordinated long-term effort. Attending this session will enable a more in-depth understanding of what Idahoans think about the condition, management and various uses of rangelands and the importance of this type of effort for landscape scale rangelands management.

DIVERSITY OF PUBLIC LANDS RANCHERS BASED ON SOCIAL AND ECONOMIC CHARACTERISTICS. Brianne N. Lind*[1], John A. Tanaka[2], Kristie Maczko[3]; [1]University of Wyoming/Sublette County Conservation District, Pinedale, WY, [2]University of Wyoming, Laramie, WY, [3]University of Wyoming, Fort Collins, CO

Public lands ranchers make essential social and economic contributions throughout many rural communities across the United States. Numerous challenges face ranchers utilizing public lands potentially causing associated challenges in community settings. Ranching operations are very diverse and may not react similarly to changes. Reliable information documenting characteristics of public lands ranchers is needed to help land managers and policy makers understand ranchers' economic and social diversity, the diversity of operations, and the contributions to local communities. A survey offers the best method to gather nationwide data on public lands ranchers. This study used a mail survey to obtain social and economic data needed to determine the diversity among ranchers. Three thousand thirty surveys were mailed to public land permittees nationwide, with a thirty-seven percent response rate.

Cluster analysis was used to determine different rancher groups in both studies and the groups were then compared to one another on social and economics as well as reactions to hypothetical public land policy changes. It was found that rancher groups are diverse and can be classified into different groups based on the social and economic data collected. Also discovered was that the various rancher groups respond differently to public lands grazing policies. The results of this study are currently in the process of being published in peer-reviewed literature that will be accessible to federal agencies like the Bureau of Land Management and the United States Forest Service along with other public lands managers. All who value public lands are affected by decisions regarding management. Therefore, it is essential that reliable information is gathered on all public land resource aspects- social, economic, and ecological- if we are to make well-informed decisions on public land use. This survey is a start toward having statistically valid data to aid in the public lands management decision-making process.

RANCHER PERCEPTIONS OF ECOSYSTEM SERVICES ON INTERMOUNTAIN WEST RANGELANDS. Betsey York*, Mark Brunson, Kristin Hulvey; Utah State University, Logan, UT

Ecosystem services are benefits that humans obtain as a result of ecosystem processes and conditions. Rangelands in the Intermountain West are increasingly expected to provide ecosystem services to the general public as well as ranchers. Land management agencies in cooperation with ranchers have created management plans to fulfill this need. Successful plans manage for a suite of ecosystem services including those necessary for livestock production as well as ecosystem function and human appreciation. There is a need to understand the values placed on certain ecosystem services by those charged with implementing range management plans. During the summer of 2016, 11 in-person, semi-structured interviews were conducted to broadly understand the values ranchers place on ecosystem services. Interview participants were ranchers in the tri-state corner of Utah,

Idaho and Wyoming. The interviews lasted about an hour and asked general background of the operation as well as management strategies for various ecosystem services produced by their land to understand value placed. Once interviews were completed, two researchers independently analyzed transcribed interviews for common themes. A variety of services were highlighted as part of management schema and could be placed into three *management motivation categories*. The categories are: (1) livestock production, (2) heritage and legacy preservation, and (3) destiny control. These common themes seem to determine how the majority of decisions are made on livestock operations. Themes were also used to develop a survey administered in Fall 2016 to a larger sample of ranchers across the Great Basin. This research will aid agencies such as the BLM, USFS and NRCS in understanding rancher motivations for management. By understanding what resources are highly valued by ranchers, plans that include these services, as well as those desired by the public, will be developed for more widespread manager adoption.

RANCHERS AND BEAVERS: SOCIAL ASPECTS OF BEAVER-RELATED WATERSHED RESTORATION IN WESTERN RANGELANDS. Susan Charnley*[1], Raechel R. Davee[2]; [1]US Forest Service, Pacific Northwest Research Station, Portland, OR, [2]Oregon State University, Corvallis, OR

Beavers, beaver dams, and artificial structures that mimic the effects of beaver dams are potentially useful tools for restoring incised streams, improving in-stream habitat for fish, mitigating the impacts of drought, and improving the availability of water and forage for livestock in western rangelands of the USA. Beaver and beaver-related stream restoration strategies are currently gaining prominence in the American West. Although research exists on the biophysical conditions conducive to using these restoration approaches at particular sites, little research exists regarding the social factors that enable or constrain beaver and beaver-like restoration strategies. This gap is particularly apparent for western rangelands where ranchers are important users and managers of private and public lands. I draw on research with ranchers from northern Nevada, eastern Oregon, and northern California to document ranchers' perspectives on: (a) beaver-livestock interactions; (b) the impacts of beavers and beaver dams on water and range management, and on overall ranching operations; and (c) the pros and cons of beaver-related restoration tools. Most ranchers having experience with beaver-related restoration identified both benefits and drawbacks, felt that the benefits outweighed the drawbacks, and had different practices for addressing undesirable effects. However, beaver-related restoration tools alone do not suffice for achieving watershed restoration; where livestock contribute to stream incision and aquatic habitat degradation, changes in grazing practices are needed to accompany these tools. Other social issues to address in pursuing beaver-related restoration on western rangelands include legal and policy constraints associated with installing dams in streams, neighbors' views on beavers, water rights, and trapping.

CHANGING PERSPECTIVES OF USFWS REGARDING ENDANGERED SPECIES CONSERVATION AND LIVESTOCK RANCHING. Sheila Barry*[1], Theresa Becchetti[2]; [1]UCCE, San Jose, CA, [2]UCCE Stanislaus County, Modesto, CA

Rangelands are a predominant land type in California, comprising 60% of the total land area and supporting the area's most significant land use, livestock ranching. In past decades throughout the west there was strong pressure from environmental interests to remove livestock grazing from public lands. Efforts were led by radical groups such as Earth First! with battle cries such as "No more moo by '92" and "Cow free by '93," but the idea that western grazed land was damaged land was popularized by some ecologists and the media. From the 1980s and into the early 2000s, efforts to conserve special status species on rangelands often meant removing livestock ranching. In recent years livestock ranching has been shown to support biodiversity through grazing and associated rancher stewardship. This study evaluated changing perspectives of US Fish and Wildlife Service (USFWS) regarding endangered species conservation and livestock ranching through text analysis of federal register documents for 185 listed species in California associated with livestock ranching. Statements associated with livestock grazing in federal listing documents were recorded and categorized as being negative, neutral or positive towards grazing. Results indicated that at the time of listing, 1967 to current, grazing or trampling was listed as threatening 77% of the species with a ranching nexus; whereas, in current documents grazing is only listed as a threat for 28% of these species. In the majority of cases inappropriate grazing, which includes lack of grazing is now defined as the threat. Further analysis reviewed that this change in USFWS's perspective was a result of research findings, demonstration and in some cases failed conservation efforts after grazing removal.

ESTIMATING WATER TRADEOFFS OF BEEF CATTLE ON CALIFORNIA RANGELANDS. Julie Finzel*[1], Emily Andreini[2], Devii Rao[3], Stephanie R. Larson-Praplan[4], James Oltjen[2]; [1]UC Cooperative Extension, Bakersfield, CA, [2]UC Davis, Davis, CA, [3]UC Cooperative Extension, Hollister, CA, [4]UC Cooperative Extension, Santa Rosa, CA

The prolonged drought in California has caused many to take a close look at where water goes and how it is used. Agriculture and livestock production are continually criticized for using large amounts of water. A recent webinar by Friends of the Earth to health providers stated, "beef is one of the largest users of water in California agriculture, 47% of the total California footprint." Water for beef protein is reported second only to almonds. Their source (UNESCO, The Netherlands) did not take into account the ecosystem services provided by beef production on rangelands. This project seeks to provide a scientific based response that better addresses the water use by beef cattle and the ecosystem service tradeoffs provided by grazing cattle. Specifically, the project sought to quantify water use by beef cattle on California rangelands, a previously unexplored topic. We accounted for blue water–the water in freshwater lakes, rivers and aquifers; and green water– the precipitation that does not run off or recharge the groundwater but is stored in the soil or temporarily stays on top of the soil or

vegetation. A review of water use by beef cattle on rangelands in California will be presented, as well as a discussion of ecosystem services provided by managed grazing of beef cattle.

NEW DEVELOPMENT PATHWAYS FOR SOUTHERN ETHIOPIA? WEALTHY PASTORALISTS INVEST IN URBAN ASSETS. D. Layne Coppock*[1], DeeVon Bailey[1], Medhat Ibrahim[1], Seyoum Tezera[2]; [1]Utah State University, Logan, UT, [2]MARIL, PLC, Addis Ababa, Ethiopia

The Borana pastoral system has long-been regarded as a model for sustainable resource use in eastern Africa. Recent growth in human and livestock populations, however, has contributed to a marked decline in rangeland condition as well as an increasing incidence of poverty among pastoralists. Another trend has been an increase in pastoral household wealth stratification; today about 10% of the population controls 60% of the livestock. Because wealthy pastoralists are important here and have never been studied, research was conducted to assess how the wealthy perceive change in the pastoral system and how they manage their assets. Twelve in-depth interviews with elderly, influential men occurred. The interviewees perceived that the pastoral system is indeed in decline, and the most serious constraints for livestock production include chronic shortages of forage and labor. The average value of the physical and financial assets held by these men was estimated as at least USD $164,000, about 62-times that held by poor households. The average investment portfolio was comprised of livestock (two-thirds of total value), while savings accounts in local banks and urban real estate (largely housing) made up the remainder. Livestock in general, and cattle in particular, were the riskiest assets given recurrent effects of drought on animal productivity and mortality. When asked to identify future investment priorities, the men noted that investing in real estate and their children were preferred to investing in more livestock. The spread of urbanization in the rangelands has given the wealthy new options to reduce their risks of animal asset losses by investing more in non-livestock options. The latter could be important for small-town development as well as in providing incentives to improve rangeland management via destocking. Public educational programs that prominently include wealthy pastoralists as opinion leaders and mentors could help accelerate positive changes in the system.

Symposium:
Impacts of Conifer and Mesquite Encroachment and Management on Grouse in the Intermountain West and Great Plains

TARGETED WOODLAND REMOVAL TO RECOVER AT-RISK GROUSE AND THEIR SAGEBRUSH-STEPPE AND PRAIRIE ECOSYSTEMS. Richard F. Miller*[1], David Naugle[2], Jeremy D. Maestas[3], Christian Hagen[4], Galon Hall[5]; [1]Oregon State University, Corvallis, OR, [2]University of Montana, Missoula, MT, [3]USDA-NRCS, Redmond, OR, [4]OSU, Bend, OR, [5]USDA-NRCS, Washington DC, MD

Widespread degradation of sagebrush and prairie ecosystems in western North America has resulted in the loss of ecosystem function and resilience posing enormous conservation challenges. Threats vary in intensity across the region, but the most extensive top-down stressors impacting these shrub and grassland ecosystems include conversion of native rangelands to row crop agriculture, residential subdivision, energy, mining and other industrial developments, woodland expansion, conversion from native vegetation to invasive species, and altered wildfire regimes. This and the following presentations will focus on the effects of expanding woodlands and their management on grouse populations, one of the few practices available to rapidly restore otherwise suitable habitats. During the first pinyon and juniper symposium held in Logan Utah in 1975, it was made clear that we knew little about the impacts of woodland management on wildlife, with the exception of deer winter range. Over the years we have learned a considerable amount about the impacts of woodland encroachment into shrub-steppe and grasslands on ecosystem function and resilience. However, only recently has research evaluated the direct impacts of conifer and mesquite encroachment and management on grouse behavior and survival, and recolonization following vegetation treatments. This paper will very briefly summarize these results and then address the question; Is managing for grouse an opportunity or hindrance in restoring ecosystem function?

A HIERARCHICAL PERSPECTIVE TO WOODY PLANT ENCROACHMENT FOR CONSERVATION OF PRAIRIE-CHICKENS. Sam Fuhlendorf*[1], Torre J. Hovick[2], R. Dwayne Elmore[1], Ashley Tanner[1], Dave Engle[1], Craig A. Davis[1]; [1]Oklahoma State University, Stillwater, OK, [2]North Dakota State University, Fargo, ND

Encroachment of Great Plains grasslands by fire-sensitive woody plants is a large-scale, regional process that fragments landscapes. In a recent REM paper (Fuhlendorf et al. 2017), we use two prairie grouse species (*Tympanuchus* spp.) of conservation concern, and apply hierarchy theory to demonstrate how regional processes constrain lower level processes and reduce the success of local management. For example, fire and grazing management may be locally important to conservation, but they rarely cause irreversible fragmentation of grasslands in the Great Plains. Multiple disturbance processes cause short term alterations in vegetation conditions that can be positive or negative but from a long-term perspective it maintains large tracts of continuous rangelands by limiting woody plant encroachment. We maintain that conservation emphasis should be focused on landscape processes that contribute to landscape fragmentation such as increased dominance of trees, and that short term effects of fire and grazing on vital rates are less important to grouse population persistence.

PINYON AND JUNIPER ENCROACHMENT INTO SAGEBRUSH ECOSYSTEMS IMPACTS DISTRIBUTION AND SURVIVAL OF GREATER SAGE-GROUSE. Peter S. Coates*[1], Brian G. Prochazka[1], Mark A. Ricca[1], Ben Gustafson[1], Pilar Ziegler[2], Michael L. Casazza[1]; [1]USGS, Dixon, CA, [2]Bureau of Land Management, Carson City, NV

In sagebrush (*Artemisia* spp.) ecosystems, encroachment of pinyon (*Pinus* spp.) and juniper (*Juniperus* spp.; hereafter, "pinyon-juniper") trees has increased dramatically since European settlement. Understanding the impacts of this encroachment on behavioral decisions, distributions, and population dynamics of greater sagegrouse (*Centrocercus urophasianus*) and other sagebrush obligate species could help benefit sagebrush ecosystem management actions. We employed a novel two-stage Bayesian model that linked avoidance across different levels of pinyon-juniper cover to sage-grouse survival. Our analysis relied on extensive telemetry data collected across 6 yr and seven subpopulations within the Bi-State Distinct Population Segment (DPS), on the border of Nevada and California. The first model stage indicated avoidance behavior for all canopy cover classes on average, but individual grouse exhibited a high degree of heterogeneity in avoidance behavior of the lowest cover class (e.g., scattered isolated trees). The second stage modeled survival as a function of estimated avoidance parameters and indicated increased survival rates for individuals that exhibited avoidance of the lowest cover class. A post hoc frailty analysis revealed the greatest increase in hazard (i.e., mortality risk) occurred in areas with scattered isolated trees consisting of relatively high primary plant productivity. Collectively, these results provide clear evidence that local sage-grouse distributions and demographic rates are influenced by pinyon-juniper, especially in habitats with higher primary productivity but relatively low and seemingly benign tree cover. These habitats may function as ecological traps that convey attractive resources but adversely affect population vital rates. To increase sage-grouse survival, our model predictions support reducing actual pinyon-juniper cover as low as 1.5%, which is lower than the published target of 4.0%. These results may represent effects of pinyon-juniper cover in areas with similar ecological conditions to those of the Bi-State DPS, where populations occur at relatively high elevations and pinyon-juniper is abundant and widespread.

ENCOUNTERS WITH PINYON-JUNIPER INFLUENCE RISKIER MOVEMENTS IN GREATER SAGE-GROUSE ACROSS THE GREAT BASIN. Brian G. Prochazka[1], Peter S. Coates[1], Mark A. Ricca*[1], Michael L. Casazza[1], Ben Gustafson[1], Josh M. Hull[2]; [1]USGS, Dixon, CA, [2]University of California, Davis, Davis, CA

Fine-scale spatiotemporal studies can better identify relationships between individual survival and habitat fragmentation so that mechanistic interpretations can be made at the population level. Recent advances in Global Positioning System (GPS) technology and statistical models capable of deconstructing high-frequency location data have facilitated interpretation of animal movement within a behaviorally mechanistic framework. Habitat fragmentation due to singleleaf pinyon (*Pinus monophylla*; hereafter pinyon) and Utah juniper (*Juniperus osteosperma*; hereafter juniper) encroachment into sagebrush (*Artemisia* spp.) communities is a commonly implicated perturbation that can adversely influence greater sage-grouse (*Centrocercus urophasianus*; hereafter sage-grouse) demographic rates. Using an extensive GPS data set (233 birds and 282,954 locations) across 12 study sites within the Great Basin, we conducted a behavioral change point analysis and constructed Brownian bridge movement models from each behaviorally homogeneous section. We found the probability of encountering pinyon-juniper among

adults was two and three times greater than that of yearlings and juveniles, respectively. However, the movement rate in response to the probability of encountering pinyon-juniper trees was 1.5 times greater for juveniles. Parameter estimates indicated a 6.1% increase in the probability of encountering pinyon-juniper coupled with a 6.2 km/hour increase in movement speed resulted in a 56%, 42% and 16% increase in risk of daily mortality, for juveniles, yearlings, and adults, respectively. The effect of pinyon-juniper encounters on survival was dependent on movement rate and differed among age class. Under fast speed movements (i.e., flight), mortality risk increased as encountering pinyon-juniper increased across all age classes. In contrast, slower speeds (i.e., average) yielded similar adverse effects for juveniles and yearlings but not for adults. This analytical framework supports a behavioral mechanism that explains reduced survival related to pinyon-juniper within sagebrush environments, whereby encountering pinyon-juniper stimulates riskier movements that likely increase vulnerability to visually acute predators.

SAGE-GROUSE RESPONSE TO CONIFER REMOVAL IN THE GREAT BASIN.
Jeremy D. Maestas*[1], John Severson[2], Christian Hagen[3], David Naugle[4], Todd Forbes[5], Kerry Reese[2]; [1]USDA-NRCS, Redmond, OR, [2]University of Idaho, Moscow, ID, [3]OSU, Bend, OR, [4]University of Montana, Missoula, MT, [5]BLM, Lakeview, OR

Conifer woodlands expanding into sage-steppe (*Artemisia* spp.) are a threat to sagebrush obligate species including the imperiled greater sage-grouse (*Centrocercus urophasianus*). Conifer removal is accelerating rapidly despite a lack of empirical evidence to assess outcomes to grouse. Using a before-after-control-impact (BACI) design, we evaluated short-term effects of conifer removal on nesting habitat use by monitoring 262 sage-grouse nests in the northern Great Basin during 2010–2014. Tree removal made available for nesting an additional 28% of the treatment landscape by expanding habitat an estimated 9603 ha (3201 ha [±480 SE] annually). Relative probability of nesting in newly restored sites increased by 22% annually, and females were 43% more likely to nest within 1000 m of treatments. From 2011 (pretreatment) to 2014 (3 years after treatments began), 29% of the marked population (9.5% [±1.2 SE] annually) had shifted its nesting activities into mountain big sagebrush habitats that were cleared of encroaching conifer. Grouping treatments likely contributed to beneficial outcomes for grouse as individual removal projects averaged just 87 ha in size but cumulatively covered a fifth of the study area. Collaboratively identifying future priority watersheds and implementing treatments across public and private ownerships is vital to effectively restore the sage-steppe ecosystem for nesting sage-grouse.

SAGE-GROUSE GROCERIES: FORB RESPONSE TO PI&NTILDE;ON-JUNIPER TREATMENTS.
Jonathan Bates*[1], Kirk W. Davies[2], April Hulet[3], Richard F. Miller[4], Bruce Roundy[5]; [1]USDA-ARS, Burns, OR, [2]USDA - Agricultural Research Service, Burns, OR, [3]University of Idaho, Moscow, ID, [4]Oregon State University, Corvallis, OR, [5]Brigham Young University, Provo, UT

Juniper and piñon woodlands have increased 2 to 10-fold in nine ecoregions spanning the Intermountain area of the western United States the past 150 years. Control of these woodlands by mechanical treatments and prescribed fire has been applied since the 1950's. The Sage Grouse Initiative has made conifer removal a major part of its efforts to reestablish sagebrush habitat for sage-grouse and other shrub steppe species. We analyzed data sets from previous and ongoing studies characterizing cover response of perennial and annual forbs, consumed by sage-grouse, to mechanical, prescribed fire and fuel reduction treatments. There were 11 sites in western juniper woodlands, three sites in singleleaf piñon and Utah juniper, two sites in Utah juniper, and two sites in Utah juniper and Colorado piñon. Western juniper sites were in NW California, eastern Oregon, and SW Idaho and were located in mountain big sagebrush steppe associations. Sites for the other woodlands were in eastern Nevada and western Utah and were located in Wyoming big sagebrush associations. Site potential was a major determinant for increasing perennial forbs utilized by sage-grouse following conifer control. The cover response of perennial forbs, whether increasing or exhibiting no change, was similar regardless of conifer treatment. For sage-grouse habitat, mechanical and low disturbance-fuel reduction conifer treatments produce similar perennial forb responses compared to fire while maintaining the habitat characteristics of sagebrush steppe. Annual forbs favored by sage-grouse benefitted most from prescribed fire treatments with smaller increases following mechanical and fuel reduction treatments. Where large scale use of fire is not a management option in sage-grouse habitat, small-patchy fires to control conifers might offer opportunities to increase annual forbs and create more diverse habitat mosaic.

EXTENDING CONIFER REMOVAL AND LANDSCAPE PROTECTION STRATEGIES FROM SAGE-GROUSE TO SONGBIRDS, A WEST-WIDE ASSESSMENT. David Naugle*[1], Jason Tack[2], Patrick Donnelly[2], Kevin Doherty[3], Brady Allred[1], Victoria Dreitz[1]; [1]University of Montana, Missoula, MT, [2]U.S. Fish and Wildlife Service, Missoula, MT, [3]U.S. Fish and Wildlife Service, Denver, CO

Recent and unprecedented scale of sage-grouse conservation in the American West enables assessment of community-level benefits afforded to other sagebrush-obligate species. We use North American Breeding Bird Survey (BBS) count data and machine learning to assess predictors influencing spatial distribution and abundance of three sagebrush-obligate songbirds (Brewer's sparrow, sagebrush sparrow and sage thrasher). We quantified co-occurrence of songbird abundance with sage-grouse lek distributions using point pattern analyses and evaluated the concurrence of songbird abundance within sage-grouse habitat restoration and landscape protection. Sagebrush land-cover predictors were positively associated with the abundance of each songbird species in models that explained 16-37% of variation in BBS route level counts. Individual songbird models identified an apparent 40% threshold in sagebrush land-cover over which songbird abundances nearly doubled. Songbird abundances were positively associated with sage-grouse distributions ($P < 0.01$); range-wide, landscapes supporting >50% of males on leks also harbored 13-19% higher densities of songbirds compared to range-wide mean densities. Eighty-five percent of the conifer removal conducted through the Sage Grouse

Initiative coincided with high to moderate Brewer's sparrow abundance. Wyoming's landscape protection strategy for sage-grouse encompass half the high to moderate abundance sagebrush sparrow and sage thrasher populations. In the Great Basin half the high to moderate abundance sagebrush sparrow and sage thrasher populations coincide with sage-grouse Fire and Invasive Assessment Tool priorities where conservation actions are being focused in an attempt to reduce the threat of wildfire, and invasive plants. Our work illustrates spatially-targeted actions being implemented ostensibly for sage-grouse largely overlap high abundance centers for three sagebrush obligate passerines and are likely providing significant conservation benefits for less well-known sagebrush songbirds.

IMPACT OF MESQUITE DISTRIBUTION ON SEASONAL SPACE USE OF LESSER PRAIRIE-CHICKENS. Matthew A. Boggie[1], Cody R. Strong[1], Daniel Lusk[1], Scott A. Carleton*[2], William R. Gould[1], Randy L. Howard[3], Clay Nichols[4], Michael Falkowski[5], Christian Hagen[6]; [1]New Mexico State University, Las Cruces, NM, [2]United States Geological Survey, Las Cruces, NM, [3]Bureau of Land Management, Roswell, NM, [4]United States Fish and Wildlife Service, Arlington, TX, [5]Colorado State University, Fort Collins, CO, [6]Oregon State University, Bend, OR

Loss of native grasslands by anthropogenic disturbances has reduced availability and connectivity of habitat for many grassland species. A primary threat to contiguous grasslands is the encroachment of woody vegetation which is spurred by disturbances that take on many forms
from energy development, fire suppression, and grazing. These disturbances are exacerbated by natural and human driven cycles of changes in climate punctuated by drought and desertification conditions. Encroachment of honey mesquite (*Prosopis glandulosa*) into the prairies of
southeastern New Mexico has potentially limited habitat for numerous grassland species, including lesser prairie-chickens (*Tympanuchus pallidicinctus*). To determine the magnitude of impacts of distribution of mesquite and how lesser prairie-chickens respond to mesquite presence on the landscape in southeastern New Mexico, we evaluated seasonal space use of lesser prairie-chickens in the breeding and non-breeding seasons. We derived several remotely sensed spatial metrics to characterize the distribution of mesquite. We then used these data to create population-level resource utilization functions and predict intensity of use of lesser prairie chickens across our study area. Home ranges were smaller in the breeding season compared the non-breeding season, however, habitat use was similar across seasons. During both seasons, lesser prairie-chickens used areas closer to leks and largely avoided areas with mesquite. Relative to the breeding season, during the non-breeding season habitat use suggested a marginal increase in mesquite within areas of low intensity of use, however, aversion to mesquite was strong in areas of medium to high intensity of use. To our knowledge, our study is the first to demonstrate a negative behavioral response by lesser prairie-chickens to woody encroachment in native grasslands. To mitigate one of the possible limiting factors for lesser prairie-chickens, we suggest future conservation strategies be employed

by land managers to reduce mesquite abundance in the southern portion of their current range.

LESSER PRAIRIE-CHICKEN AVOIDANCE OF TREES IN A GRASSLAND LANDSCAPE. Joseph Lautenbach*[1], Jonathan Lautenbach[2], Daniel Sullins[3], Reid Plumb[4], David Haukos[5], Christian Hagen[6], James Pitman[7]; [1]Sault Ste Marie Tribe of Chippewa Indians, Sault Ste Marie, MI, [2]Kansas State University, Manhattan, KS, [3]Kansas State Unversity, Manhattan, KS, [4]California Department of Fish and Wildlife, Montague, CA, [5]U. S. Geological Survey, Manhattan, KS, [6]Oregon State University, Bend, OR, [7]Western Association of Fish and Wildlife Agencies, Emporia, KS

The lesser prairie-chicken (*Tympanuchus pallidicinctus*) is a species of grouse native to the southwest Great Plains that has experienced substantial population declines during the past 3 decades. Across their range, natural fire has been suppressed, leading to tree encroachment in the eastern portion of their range. Although tree encroachment has been implicated as a source of habitat loss due to the reduction of fire from much of their range, little is understood about how these affect lesser prairie-chicken ecology. During 2013 – 2016, we investigated habitat selection, space use, and survival by female lesser prairie-chickens in a landscape managed with prescribed fire where tree encroachment into grasslands is a concern. Using a resource selection framework, we found that lesser prairie-chickens have a high probability of avoiding areas with >4 trees/ha and nested in areas with <2 trees/ha. Based on selection functions, >100,000 ha of habitat may have been lost to tree encroachment in the mixed grass prairie of Kansas. In contrast to habitat selection trends, adult and nest survival were not affected by distance to nearest tree or tree density. By selecting areas with lower tree densities and at greater distances from the nearest tree, lesser prairie-chickens are likely selecting densities that reduce potential predation risk by avoiding trees. Consequently, removing trees from the landscape will increase habitat availability for lesser prairie-chickens. Ongoing mechanical tree removal efforts at the study site have been matched with increased lesser prairie-chicken use. Once trees are removed, maintaining the prairie is necessary, otherwise trees will reestablish. We found prescribed fire, when implemented within a patch-burn grazing framework, to be a viable method to control future tree encroachment. Patch-burn grazing provides nesting and brooding habitats (>2 years-post-fire), while still controlling trees. Tree removal and prescribed fire have the ability to generate and maintain lesser prairie-chicken habitat.

ECOSYSTEM WATER AVAILABILITY IN JUNIPER VERSUS SAGEBRUSH SNOW-DOMINATED RANGELANDS. Patrick R. Kormos[1], Frederick B. Pierson[2], C. Jason Williams*[3], Danny Marks[2], Stuart Hardegree[4], Scott Havens[2], Andrew Hedrick[2], Jon Bates[5], Tony Svejcar[6]; [1]USDA-ARS, Boise, ID, [2]usda ars, boise, ID, [3]usda ars, tucson, AZ, [4]usda ars, fort collins, CO, [5]USDA - ARS, Burns, OR, [6]usda ars, Burns, OR

Western Juniper (*Juniperus occidentalis* Hook.) has greatly expanded in the past 150+ years, and now dominates over 3.6 million ha of rangeland in the Intermountain Western US. The impacts of juniper encroachment on critical ecohydrological relationships among snow distribution, water budgets, plant community transitions, and habitat requirements for wildlife, such as the greater sage grouse (*Centrocercus urophasianus*), remain poorly understood. The goal of this study is to better understand how juniper encroachment affects water availability for ecohydrologic processes and associated wildlife habitat in snow-dominated sagebrush (*Artemisia* spp.) steppe ecosystems. A six year combined measurement and modeling study is conducted to explore differences in snow distribution, water availability, and annual water balances between juniper-dominated and sagebrush-dominated catchments. Although there is large interannual variability in both measured weather data and modeled hydrologic fluxes during the study, results indicate that juniper-dominated catchments have greater peak accumulations of snow water equivalent, earlier snow melt, and less streamflow relative to sagebrush-dominated catchments. Water delivery is delayed by an average of 9 days in the sagebrush-dominated scenario compared to the juniper-dominated scenario as a result of increased water storage in snow drifts. The delayed water input to sagebrush-dominated ecosystems in typical water years has wide ranging implications for available surface water, soil water, and vegetation dynamics associated with wildlife habitat for sagebrush obligates such as sage grouse. Results from this study imply that the retention of high-elevation, sagebrush-dominated landscapes may become crucial for sage grouse habitat management if mid- and low-elevation precipitation continues to transition from snow- to rain-dominated.

Oral Technical Session:
Grazing Ecology and Management

LIVESTOCK GRAZING MANAGEMENT, CONCEPTUAL MODELS, AND COMPLEX SYSTEMS THEORY. Kevin E. Jablonski*, Paul J. Meiman; Colorado State University, Fort Collins, CO

There is growing recognition that reductive and prescriptive approaches to livestock grazing management (LGM) are insufficient to meeting the challenges that producers face, and that a more holistic approach is needed. This has led to an increased interest in the application of complex systems theory to LGM research. One key step in working in any complex system is the derivation and adoption of a shared conceptual model of the system, but such a conceptual model appears to be lacking in LGM research. In this presentation I will first discuss complex systems theory, including relevant characteristics, and place LGM in a complex systems context. I will then report the results of a recently conducted systematic review wherein we examined the LGM literature for evidence of a shared conceptual model and complex systems approach. Finally, I will propose a conceptual model of LGM that has the potential to resolve many of the conflicts in the discipline, clarify terminological confusion, and serve as a unifying force for LGM research. Throughout, I will offer practical insights and applications that highlight the utility of a shared conceptual model to researchers and practitioners.

GRAZING DISTRIBUTION ON NEBRASKA SANDHILLS. Jace Stott*[1], Mitchell Stephenson[2]; [1]University of Nebraska - Lincoln, Lincoln, NE, [2]University of Nebraska - Lincoln, Scottsbluff, NE

Global Positioning Systems (GPS) have advanced the study of not only distribution patterns of free-ranging livestock but also behavioral responses to environment. Advancements have come in the ability to track livestock position at a particular time and place, as well as capabilities in detecting when and where cattle are grazing and resting. Behavioral responses and distribution are effected by many factors including: topography, water locations, forage location and variety, pasture dimensions, climate, herd dynamics, and parasitism (both external and internal). A study was conducted to track livestock behavior within 4-pasture deferred rotations with herds between 40 and 90 animals. The goal of this study was to better understand factors that affect livestock grazing patterns on Sandhills rangelands as grazing time progressed on specific pastures and over the growing season. Six cows were tracked within each herd with GPS collars at 10 min intervals from May 15 to Sept 8. Head movements were collaborated with visually-observed behavioral patterns throughout the growing season of 2016. Conditions on site that may contribute to particular behaviors or movement such as weather, parasite avoidance, or foraging behaviors were collected. Preliminary, first-year data based on visual observations showed cattle exhibiting grazing behavior 46.8 % ± 18.4 SD of time, travel 2.5% ± 2.5 SD of time, and resting behavior (including time at water, salt, licking, and rubbing) 50.6% ± 18.7 SD of time. Preliminary visual observations suggest that behavior may be influenced by fly annoyance as cattle increased time bunched together, hastened pace of foraging, and utilized brush and trees. Visual observation data will be collaborated with GPS tracking data to evaluate these visual observations and better explain cattle behaviors and distribution patterns.

EXPLORING RANGELAND HABITAT USE OF CATTLE WITH DIVERGENT MOLECULAR BREEDING VALUES FOR RESIDUAL FEED INTAKE . Carly A. Moore*[1], Nicky Lansink[1], John Basarab[2], Carolyn Fitzsimmons[3], Scott Nielsen[1], Graham Plastow[4], Edward Bork[1]; [1]University of Alberta, Edmonton, AB, [2]Alberta Agriculture and Forestry, Lacombe, AB, [3]Agriculture and Agri-Food Canada, Edmonton, AB, [4]Livestock Gentec, Edmonton, AB

Residual feed intake (RFI) is a heritable trait that can be used to measure feed efficiency in cattle and serve as a tool for managing beef operation costs. However, measures of RFI have mainly been evaluated under drylot conditions where animals are on a standardized diet with variation in foraging behaviour minimized. Evidence suggests that cattle in rangelands are highly selective while foraging, a phenomenon that applies across multiple spatial scales ranging from individual feeding stations to landscape locations. This is further affected by temporal variation in forage quality and quantity across the grazing season. Our study explored the relationships between cattle habitat selection and activity

budgets with associated molecular breeding values (MBV's) for RFI. Research was conducted at the University of Alberta Mattheis Research Ranch, 35 km north of Brooks, Alberta in the Mixedgrass Prairie. An identified subset of commercial cows with distinctly divergent (high and low) MBV's for RFI were fitted with Lotek 3300LR GPS collars and AfiAct II pedometers to track their movements while rotationally grazing a series of large pastures for five months. We hypothesized that animals with low MBV's for RFI (efficient) would utilize areas associated with higher quality forage for greater periods and spend less time moving, excluding travel to food or water sources, than animals with high MBV's for RFI (inefficient). Behavioural data for each animal and treatment group was used to develop resource selection functions (RSFs) for identified cattle. Environmental factors contributing to seasonal selection of areas in pastures will be compared between low and high RFI group animals. We will discuss differences in habitat use between RFI groups and the potential implications for the use of breeding values for RFI in extensively managed cow/calf operations

TESTING PERFORMANCE OF RFI-SELECTED CATTLE UNDER EXTENSIVE COW/CALF PRODUCTION SYSTEMS. Nicky Lansink*[1], Carly A. Moore[1], John Basarab[2], Carolyn Fitzsimmons[3], Graham Plastow[4], Edward Bork[1]; [1]University of Alberta, Edmonton, AB, [2]Alberta Agriculture and Forestry, Lacombe, AB, [3]Agriculture and Agri-Food Canada, Edmonton, AB, [4]Livestock Gentec, Edmonton, AB

Residual feed intake (RFI) is a moderately heritable trait that can be used to measure feed efficiency in beef cattle, and thereby reduce feed related costs. RFI has been primarily evaluated under drylot conditions where diet, feed intake and activity levels are controlled and foraging behavior is eliminated. Although previous studies have tried to measure RFI on monoculture pasture, it is difficult to accurately determine individual feed intake. The objective of this study was to determine whether there is a difference in performance (weight gain, backfat recovery and methane production) between cattle with molecular breeding values (MBVs) for high and low RFI when foraging under open range conditions. This research was conducted at the University of Alberta Mattheis Ranch. A total of 450 commercial Hereford/Angus cows, with predicted MBVs for RFI, were separated into groups of high, low and medium efficiency. High RFI cows were bred to high RFI bulls, low RFI cows were bred to low RFI bulls and medium RFI cows were bred to medium RFI bulls, where the bulls had their own RFI phenotypes to produce groups of high, low and medium RFI calves. Production metrics, such as cow weight gain, backfat recovery, and breeding interval, along with calf growth, were collected for the 2015 grazing season. A subset of 60 replacement heifers, selected based on the MBVs of associated dams (30 high and 30 low RFI), were tested for actual feed intake and methane production using GrowSafe and GreenFeed technologies, respectively. A smaller subset of 18 heifers were tested for methane production in June 2016 while grazing forage oat pasture using an open-path laser system. The presentation will further describe the results and show whether there is a significant difference in weight gain, backfat recovery and methane production between high and low RFI cattle.

BEHAVIOR OF RARAMURI CRIOLLO VS. ANGUS-CROSSBRED COWS IN RELATION TO DESERT SUMMER AMBIENT HEAT CONDITIONS. Shelemia Nyamurekunge*[1], Andres F. Cibils[1], Rick E. Estell[2], Alfredo L. Gonzalez[2], Diego E. Cano[3], Sheri Spiegal[2]; [1]New Mexico State University, Las Cruces, NM, [2]USDA ARS, Las Cruces, NM, [3]Universidad Autonoma Ciudad Juarez, Ciudad Juarez, Mexico

Cattle in the Chihuahuan Desert are exposed to extreme temperatures during certain times of year. We examined relationships between temperature and behavior for Angus Hereford (AH) and Raramuri Criollo (RC) cattle. We monitored 10 mature nursing cows of each breed that grazed separately in each of two adjacent pastures (1190ha, 1165ha) during July 2015 for 26 days. Five individuals per group were fitted with Lotek 3300 GPS collars set to record location and temperature at 10 min intervals. Collar temperature sensors were located on the GPS motherboards within plastic encasements that hung below the animals' necks. Sensors were presumed to record ambient temperature in the proximity of the collared animal. We calculated distance traveled, movement velocity, time spent within 100m of water, vegetation selection, and collar temperature during the hottest (1:00-3:00PM; H) and coolest (6:00 – 8:00AM; C) hours of each day. We also calculated the difference between temperature readings recorded by the collars and by a weather station located 3 km away. We used a repeated measures mixed ANOVA to quantify differences between the breeds' distribution, behavior, and temperature. Each collared cow was treated as an experimental unit. During H hours, RC cows traveled 40 m farther (P<0.01), moved 4.7 m/min faster (P<0.01), spent less time close to water (-18 min; P<0.01), exhibited higher preference for vegetation types with least shade (bare ground, P<0.01), and had collar temperatures that were 1.3 oC hotter (P<0.01) than AH counterparts. Temperature differences between collar and weather station records for H hours was also greater for RC (+ 2.7 oC) than for AH (+1.5 oC) cows (P<0.01). During C hours, differences between breeds were either considerably smaller or non-existent. With our preliminary data analysis, RC cows may be better able to withstand the hot summers of the Chihuahuan Desert compared to commonly-used British crossbreds.

NUTRITIONAL STATE INFLUENCES TREMBLING ASPEN (*POPULUS TREMULOIDES)* INTAKE BY SHEEP. Kristen Y. Heroy*[1], Beth A. Burritt[1], Samuel B. St. Clair[2], Juan J. Villalba[1]; [1]Utah State University, Logan, UT, [2]Brigham Young University, Provo, UT

Browsing by ungulates is one cause of aspen decline in western North America. The goal of this study was to explore the influence of an herbivore's nutritional state on aspen intake. Thirty-two lambs were penned individually and randomly assigned to two groups (16 lambs/group). Group 1 received freshly harvested leaves of an aspen stand with high content (AH) (21.2%) of phenolic glycosides (PG)— a chemical defense— whereas Group 2 received leaves of an aspen stand with low concentration (AL) (16.3%) of PG. For Experiment 1, half of the animals in each group were offered a ration of low (L1) crude protein (CP):energy (DE) ratio (CP/DE) (CP: 10.7%, DE: 3.13 Mcals), and the

other half received a ration of high (H1) CP/DE (CP: 20.3%, DE: 3.13 Mcals). During Experiment 2, lambs were re-randomized and half of the animals in each group received a ration of high (H2) DE/CP (CP: 13.43% DE: 3.45 Mcals), and the other half received a ration of low (L2) DE/CP (CP: 13.33% DE: 2.52 Mcals). In Experiment 1, aspen intake was greater when animals received H1 than when they received L1 (p=0.02), and when they had AL than when they had AH (p=0.009). In Experiment 2, aspen intake was greater in L2 than in H2 (p=0.001). In summary, lambs under a basal diet high in protein ate more aspen likely due to the beneficial effects of protein on detoxification processes and to the need for additional energy intake. In contrast, a basal diet high in energy led to lower aspen intake likely because satiety induced by calories reduced appetite for less desirable –and defended– forages like aspen. Thus, herbivores grazing an understory with high protein/energy ratios are more prone to consume greater amounts of aspen than those animals grazing understories of greater energy and lower protein content.

MOVING FROM AVOIDANCE TO ACTIVELY MANAGED GRAZING IN LARKSPUR HABITAT. Kevin E. Jablonski*[1], Paul J. Meiman[1], Joel Vaad[2]; [1]Colorado State University, Fort Collins, CO, [2]Colorado State University, Livermore, CO

The many species of larkspur (*Delphinium* spp.) are among the most dangerous poisonous plants on rangelands in the western United States, causing death losses estimated at 2-5% (sometimes as much as 15%) per year for cattle grazing in larkspur habitat. Other effects, such as altered grazing management regimes and consequent lost forage quantity and quality, are significant but poorly understood. In the face of these consistent losses, range scientists have spent more than a century
studying *Delphinium* species, resulting in significant progress in our understanding of the biology of many species but limited progress on overall losses. The current best practice recommendation focuses on seasonal avoidance of grazing in larkspur habitat, but creates problems of its own by limiting access to pastures during the most productive time of year. Growing evidence suggests that it instead may be possible to graze at any time, regardless of plant toxicity. In this presentation I will report on an ongoing multi-level study of Geyer larkspur (*Delphinium geyeri*), wherein we are incorporating experimental evidence, case study data, agent-based modeling, and a complex systems approach to derive new adaptive strategies for grazing in larkspur habitat.

MANAGING FOR A VARIABLE CLIMATE: THE EFFECT OF DIFFERENT GRAZING STRATEGIES ON LONG TERM PROFITABILITY AND SUSTAINABILITY IN THE SEMI-ARID SAVANNAS OF NORTHERN AUSTRALIA. Peter J. OReagain*[1], John J. Bushell[1], Joe Scanlan[2], Lester Pahl[2], Angela Anderson[1]; [1]Department of Agriculture and Fisheries, Charters Towers, Australia, [2]Department of Agriculture and Fisheries, Toowoomba, Australia

Rainfall variability is a major challenge to sustainable and profitable beef production in northern Australia. Strategies to manage for variability exist, but adoption by managers is

hindered by the perceived incompatibility of profitability and sustainability. Accordingly, a large (1042 ha), long-term trial was established to quantify the effects of different grazing strategies on profitability and land condition. Strategies included fixed stocking with heavy and moderate stocking rates, moderate stocking with rotational wet season spelling and flexible/variable stocking. This paper presents a brief summary of results from the first 19 years of this ongoing trial. Rainfall varied markedly over the course of the trial (range: 246-1240 mm) with some extreme drought years. After 19 years, pasture condition was best under fixed moderate stocking and rotational spelling, but by far the worst under heavy stocking. Pasture condition was intermediate under variable/flexible stocking due to the legacy effects of a single episode of overstocking preceding a major drought in 2002.

Individual animal production was highest under moderate stocking rates with these animals also receiving market premiums at the meatworks. In contrast, total animal production was highest under heavy stocking but this strategy required expensive drought feeding and destocking in a number of years. Consequently, after 19 years the accumulated gross margin of the heavy stocking strategy was less than one third that of the other strategies. Bio-economic modelling confirmed that these trends would also apply at the whole-of-property level. The present results are the first objective data in Australia to show that recommended strategies such as fixed moderate stocking, varying stock numbers in response to forage availability and fixed moderate stocking in conjunction with wet season resting are both more sustainable and profitable than heavy stocking.

HOW TOTAL REST, MANAGED REST, AND NO ACTIVE GROWING SEASON REST AFFECT BARE GROUND. Gregg E. Simonds*; Open Range Consulting, Park City, UT

Using geospatial analysis, bare ground was compared to varying rates of rest over entire landscapes and over a decade of time. The effect of these different types of management not only affected bare ground but dramatically effected soil carbon and management economics as well.

MANAGEMENT PRACTICES, HOW DO THEY AFFECT THE LAND AND HOW DO WE KNOW? Mike T. Anderson*[1], Gregg E. Simonds[2], Eric D. Sant[2]; [1]Open Range Consulting, Salt Lake City, UT, [2]Open Range Consulting, Park City, UT

In the world of range management there are countless different ways of managing. For continued rangeland improvement two questions should be kept in mind. Do different land management practices lead to different results and how do we measure those results? In the summer of 2015 we explored these questions across 5 ranches in New Mexico using remotely sensed data. To understand the effects of range management we

quantified the percent of functional ground cover (bare ground, herbaceous plants, litter and half trees/shrubs), across each ranch. This gave us the ability to see management effects both temporally and spatially. The results indicate that different management practices do indeed have different effects on the land.

YEAR TO YEAR VARIABILITY OF INDIVIDUAL COW DISTRIBUTION PATTERNS: IMPLICATIONS TO GENETIC IMPROVEMENT. Michael F. Millward*[1], Derek W. Bailey[2], Milt G. Thomas[3], Scott E. Speidel[4], Mark Enns[3], Larry Howery[5]; [1]New Mexico State University, Las Cruces, NM, [2]New Mexico State University, Las Cruces, NM, [3]Colorado State University, Fort Collins, CO, [4]Department of Animal Sciences Colorado State University, Fort Collins, CO, [5]University of Arizona, Tucson, AZ

Ongoing research suggests that cattle grazing distribution could be improved through genetic selection. One of the keys for this proposed management approach to be successful is that cattle grazing patterns should be relatively repeatable over time. The objective of this study was to determine the similarity of individual cow grazing patterns recorded during different years. Seventeen mature Brangus cows were tracked from late January to mid-March 2015 in a 3700 ha pasture in the Chihuahan Desert. As part of other studies, seven of these cows were tracked previously in this pasture during late June through July 2011, and the other 10 cows were tracked from December 2012 through January 2013. Positions were recorded at 10 minute intervals using global positioning collars. Two types of indices were used to describe cattle grazing patterns based on slope and horizontal and vertical distance to water. One type of index used ratios comparing individual cow patterns to her contemporaries, while the other compared terrain use to expected grazing patterns based on literature reviews. The correlation between the ratio-based rolling index from 2015 tracking and the previous tracking was 0.42 (P = 0.09). The correlation of pasture use between the two tracking periods was 0.29 (P = 0.26). Although the grazing patterns were recorded at least two years apart and during different months of the year, cattle that grazed pasture locations far from water during the first tracking period often used these areas during the second period. Although this initial study is promising, more research is needed to evaluate the repeatability of cattle grazing distribution patterns.

Oral Technical Session:
Grazing, Wildlife and Rangeland Interactions

IMPACTS OF ALTERNATIVE RANGELAND MANAGEMENT REGIMES ON THE ECOLOGY OF GREATER PRAIRIE-CHICKENS. Lance B. McNew*[1], Virginia Winder[2], Brett K. Sandercock[3]; [1]Montana State University, Bozeman, MT, [2]Benedictine College, Atchison, KS, [3]Kansas State University, Manhattan, KS

Population declines of grassland birds over the past 30 years have corresponded with the widespread implementation of intensive rangeland management practices (IESB) that create homogenous grassland habitats. Patch-burn grazing (PBG) was tested as an alternative management technique that is ecologically similar to historically heterogeneous fire and grazing regimes, and holds promise as a rangeland management tool that may benefit grassland wildlife. We conducted a 3-year study to compare demography and space use of greater prairie-chickens, an umbrella species for tallgrass prairie conservation, on study areas managed with PBG and areas managed with IESB in the Flint Hills of Kansas. We observed multiple lines of evidence supporting conservation value of patch-burn grazing for greater prairie-chickens. Nest survival for prairie-chickens was largely determined by vertical nesting cover, which was directly affected by rangeland management. Mean nest survival on patch-burn properties was twice as high as that on IESB properties. Our results also suggest that the interaction between fire application and stocking rates influences the space use decisions of female prairie-chickens. PBG created preferred habitats for female prairie-chickens with a 3-year fire return interval and a mosaic of burned and unburned patches, and females selected for PBG areas for both foraging and nesting. Our analysis of annual and seasonal survival and mortality risk showed that PBG practices provide habitat conditions that increase female survival during both breeding and nonbreeding seasons. Overall, populations of prairie-chickens in Kansas were not viable with current rates of population decline, and declines were predicted to be ~40% greater under IESB management compared to PBG. Our results join a growing body of evidence that rangeland management strategies that mimic historical heterogeneous fire and grazing regimes benefit native prairie wildlife.

NORTHERN BOBWHITE DENSITIES IN RELATION TO EXPERIMENTAL GRAZING REGIMES IN SOUTH TEXAS. Andrea Bruno*[1], Leonard A. Brennan[2], Micheal L. Morrison[3], Eric D. Grahmann[2], Andrew N. Tri[4], Tyler A. Campbell[5]; [1]Texas A&M University-Kingsville, Hebbronville, TX, [2]Texas A&M University-Kingsville, Kingsville, TX, [3]Texas A&M University, College Station, TX, [4]Minnesota Department of Natural Resources, Grand Rapids, MI, [5]East Foundation, San Antonio, TX

Explaining the interaction between grazing management and wildlife on rangelands requires isolating effects within a complex biophysical system. Variables such as precipitation, range site productivity, and soils are further confounded by human decision making in real world grazing operations. In South Texas, northern bobwhites (*Colinus virginianus*) commonly occur on lands where grazing and hunting are integral parts of the ranch's viability and longevity. A large-scale monitoring project was developed to assess the impact of different cattle grazing regimes on bobwhite density and vegetation structure over 4 treatment pastures (18,989 acres; continuous and rotations at medium and low stocking rates) and 3 reference sites (10,789 acres) on East Foundation lands in Jim Hogg County, Texas. Our primary objectives are to compare (1) bobwhite densities and (2) vegetation parameters both before and during-treatment on all sites, December 2014–2017. We estimated pre-grazing bobwhite density using line-transect distance sampling via helicopter between December 2014 and 2015. After 2 years of deferment,

cattle were stocked on treatment sites in late December 2015. We obtained measurements of vegetation structure, forage standing crop, and grazing intensity during the autumn and summer of 2014−2016. Bobwhite density estimates pooled across the treatments areas increased by 175% from 2014 (0.20 quail per acre; 95% CI = 0.15–0.26) to 2015 (0.55; 95% CI = 0.47–0.64). Density estimates within years among the 4 treatments were similar. On the reference sites, bobwhite density increased by 35% from 2014 (0.22; 95% CI = 0.16–0.30) to 2015 (95% CI = 0.22–0.34). This study will aid managers in understanding how cattle grazing practices and vegetation structure interact to affect bobwhite densities on a population-wide scale.

VOLUNTARY CONSERVATION IN LIEU OF THE ENDANGERED SPECIES ACT: OREGON RANCHERS AND GREATER SAGE-GROUSE. Katherine Wollstein*, Emily Jane Davis; Oregon State University, Corvallis, OR

Greater sage-grouse (*Centrocercus urophasianus*) have broad public value in the American West and represent many intersecting issues affecting rangeland health and productivity. When the U.S. Fish and Wildlife Service (USFWS) determined that the species did not warrant listing under the Endangered Species Act (ESA) in 2015, the agency recognized the coordinated effort in Oregon involving private landowners, nongovernmental organizations, and state and federal agencies effectively reducing threats to the species. This effort to preclude an ESA listing of sage-grouse on Oregon's rangelands appears to follow a worldwide trend toward more participatory and flexible governance: new roles have emerged for both the state and private landowners through use of voluntary arrangements in lieu of government regulation. Through a mixed-methods critical case study of voluntary sage-grouse conservation efforts on private ranch lands in Lake County, Oregon, decision-making power and flexibility for implementers at the local-level were explored. Twenty-four in-depth, semi-structured interviews with agency staff, government officials, and ranchers whose operations include private rangelands were conducted, focusing on documenting how these actors implement sage-grouse conservation, if and how they have power and flexibility to act, and what they perceive as sources of constraints and limitations. Qualitative analysis of interviews, documentation, and public records found that while there is flexibility and a degree of autonomy at the lower levels of this governance arrangement, rancher subscription to voluntary programs is characterized by an interactive, collaborative planning process facilitated by landowner and agency leadership. This study suggests that by granting landowners and local-level agency staff flexibility in implementation of sage-grouse conservation, voluntary arrangements may offer an appealing alternative to use of the ESA on rangelands used for cattle production.

RELATIONSHIPS AMONG SPRING LIVESTOCK GRAZING, SAGE-GROUSE NEST FATE, AND CLIMATE IN SAGEBRUSH-STEPPE COMMUNITIES. Janessa C. Julson*[1], Karen Launchbaugh[1], Courtney Conway[2], Eva Strand[1], Anthony Locatelli[1]; [1]University of Idaho, Moscow, ID, [2]U.S. Geological Survey, Moscow, ID

A recent focus on sagebrush-obligate species has increased the need to understand sagebrush-steppe habitat for rangeland and wildlife management. We explored the influence of plant community attributes on nest fate of greater sage-grouse (*Centrocercus urophasianus*) in the Snake River Plain of Southern Idaho. Perennial bunchgrass height, and cover of forbs, grasses, and shrubs were examined across various ecological sites at four study locations. All study sites had an overstory of Wyoming big sagebrush (*Artemisia tridentata* subsp. *wyomingensis*) or low sagebrush (*A. arbuscula*) with a perennial bunchgrass understory and a variety of native forbs. Vegetation sampling occurred on three plot types (nest, nest patch, and random) during the sage-grouse nesting period (i.e., mid-April to June) for three years (2014-2016). Nonmetric multidemsional scaling (NMS) and the multiple-response permutation procedure (MRPP) were used to identify patterns among the plant communities. MRPP was also used to explore the relationship between nest fate and habitat characteristics as mediated by spring livestock grazing. Preliminary analyses showed a difference in grass height between grazed and ungrazed pastures, while no difference in grass height was detected between successful and unsuccessful sage-grouse nests. Additional detail will be reported regarding variation among these attributes with respect to ecological site, yearly climatic conditions, and grazing patterns and how these characteristics relate to whether a nest was successful or not.

EFFECTS OF TIME-CONTROLLED, LIVESTOCK GRAZING ON HABITAT OF SOUTHWESTERN WILLOW FLYCATCHERS IN WEST-CENTRAL ARIZONA.
Zachary Smalls*[1], Larry Howery[1], Stuart Tuttle[2], George Ruyle[1], Bob Steidl[1]; [1]University of Arizona, Tucson, AZ, [2]NRCS, Flagstaff, AZ

The southwestern willow flycatcher (*Empidonax traillii extimus*) is an endangered subspecies distributed throughout riparian forests of the southwestern United States. Many factors, including improper livestock grazing practices, have been implicated in the decline of this species. Our goal of this study is to determine the effects of time-controlled, livestock grazing on vegetation characteristics important to the habitat of southwestern willow flycatchers in west-central Arizona. Currently, livestock grazing is only allowed outside of the growing season in areas delineated as critical habitat by USFWS, and NRCS (through their Working Lands for Wildlife Initiative) is anxious to help ranch operators and landowners develop sustainable practices in these areas. Beginning in summer 2015, we began conducting vegetation surveys on two cattle ranches in west-central Arizona, measuring vegetation attributes during three sampling periods: before livestock grazing, after livestock grazing, and at the end of the growing season. We measured: 1) species composition for main herbaceous and woody plants, 2) woody canopy cover, 3) utilization of woody and herbaceous plants, 4) density of woody seedlings, and 5) volume of non-seedling woody plants. Preliminary data indicate that species composition and cover were relatively stable across most sampling periods. Time-controlled livestock grazing up to a maximum of 12 days resulted in very low utilization rates of <12% for both herbaceous and woody plants across all sampling periods. Herbivory by livestock and wildlife, and episodic precipitation events likely contributed to considerable fluctuations observed in woody seedling density.

INFLUENCE OF BLACK-TAILED PRAIRIE DOG HERBIVORY ON RANGELAND FORAGE QUALITY AND QUANTITY. Lauren Connell*[1], Lauren Porensky[2], Derek Scasta[1]; [1]University of Wyoming, Laramie, WY, [2]USDA-ARS, Fort Collins, CO

Black-tailed prairie dogs (*Cynomys ludovicianus*) have high dietary overlap with livestock, which can cause forage-centric conflicts between agriculture and conservation. However, research suggests prairie dog–livestock relationships may mimic historic prairie dog–bison relationships, perhaps due to enhanced forage quality on prairie dog colonies. It remains unclear how the strength of trade-offs between quality and quantity varies throughout the growing season, or the degree to which increased forage quality is caused by altered species composition versus altered plant physiology. To assess the effects of prairie dog herbivory on forage in northeast Wyoming, we collected samples on and off prairie dog colonies during June, July, and August 2016 for forage quality, and August 2016 for biomass. To isolate mechanisms affecting forage quality, we collected both composite samples of all herbaceous species, and samples of western wheatgrass (*Pascopyrum smithii*, PASM). For crude protein (CP), total digestible nutrients (TDN), *in vitro* true digestibility, and calcium, prairie dog colonies had significantly higher values than control sites (5-68% greater, all p-values < 0.05, except PASM-TDN: $p = 0.15$). The effects of prairie dogs on forage quality did not vary seasonally for PASM samples (all treatment*time p-values ≥ 0.1), but for composite samples, the effects of prairie dogs on CP and calcium shifted as the growing season progressed (treatment*time $p < 0.01$ and $p = 0.02$, respectively). There was no statistically significant difference in biomass between prairie dog towns (30.75 ± 12.37 g/m2) and control sites (72.57 ± 19.24 g/m2; $p = 0.21$) due to variability among sites; however, on average prairie dog colonies contained half the biomass of control sites. Our results demonstrate enhanced forage quality on prairie dog colonies is due to both compositional and phenological shifts associated with prairie dog herbivory, and that enhanced forage quality may help offset reduced forage quantity.

LANDOWNER PERSPECTIVES OF A LIVESTOCK-WILDLIFE CONFLICT IN PATAGONIA, CHILE. Fidel Hernandez*[1], Derek Corcoran[2], Giorgia Graells[2], Carlos Rios[3], Michelle Downey[4]; [1]Caesar Kleberg Wildlife Research Institute, Kingsville, TX, [2]Ciencia Austral, Punta Arenas, Chile, [3]Institute of Patagonia, Punta Arenas, Chile, [4]Pheasants Forever, Scobey, MT

Biodiversity is an important ecosystem service provided by rangelands. However, the close link between biodiversity and rangelands sometimes results in human-wildlife conflicts. One example is the livestock-guanaco (*Lama guanicoe*) conflict occurring in southern Chile. Guanacos are a culturally and ecologically important species of the Patagonian steppe; however, conflict with sheep ranching exists because the diets of sheep and guanacos overlap considerably resulting in interspecific competition. We assessed rancher perspectives toward traditional land use practices and biological conservation to identify incentives for, and barriers to, biodiversity and guanaco

conservation. Ranchers strongly valued the importance of biodiversity and demonstrated stronger support for the cultural value, rather than the economic value, of guanacos. The promotion of sustainable harvest therefore may not be an effective conservation tool for the species in this region.

EFFECT OF FERAL HORSES, LIVESTOCK, AND WILDLIFE USE OF SPRINGS IN NORTHEASTERN CALIFORNIA . Laura K. Snell*[1], David F. Lile[2], Roger A. Baldwin[3]; [1]University of California, Alturas, CA, [2]UC Cooperative Extension, Susanville, CA, [3]University of California Agriculture and Natural Resources, Davis, CA

Wild horses heavily occupy two distinct areas of northeastern California, part of the Modoc National Forest known as the Devil's Garden and eastern Lassen County managed primarily by the Bureau of Land Management. Both horse herds have significantly exceeded appropriate management levels established in the 1971 Wild Horse and Burro Act. This increase in herd size and season long unmanaged grazing has promoted concern about resource degradation. Natural spring and seep locations are unique niche ecosystems needed to sustain a variety of life in these areas and are particularly hard hit. This study aims to quantify the relative frequency, duration, and timing of use by horses, permitted livestock, and wildlife at spring locations. We also aim to quantify riparian health standards including vegetation changes such as stubble height, plant community, bare ground, and stream bank disturbance. Ten representative study locations were selected in both the Devil's Garden and East Lassen areas. Motion sensitive cameras were deployed at each location for 14-day sampling periods during the spring, summer, and fall of 2015 and 2016. Vegetative sampling and a qualitative wild horse assessment were completed during each sampling period. This presentation will discuss initial occupancy data and vegetation analysis as well as implications for management and on-going research.

SAFETY AND USE OF GPS COLLARS ON FREE-ROAMING EQUIDS - A REVIEW. Jacob D. Hennig*, Jeffrey L. Beck; University of Wyoming, Laramie, WY

Information obtained from vertebrates equipped with Global Positioning System (GPS) transmitters has improved our understanding of spatially-related information including movement patterns, resource selection, and demographic processes globally. Such knowledge of free-roaming equids (burros and horses) in the United States, however, is lacking. Due to safety concerns, GPS neck collars have not often been used on free-roaming horses under the jurisdiction of the Bureau of Land Management. Recent designs however, have potentially made GPS collars safe for free-roaming equids. This development is underscored by Collins et al. (2014) whom recently deployed GPS collars on privately-owned and free-roaming horses in the northwestern United States, concluding that neck collars can be safely used on horses with low risk of injury or death. To better understand whether GPS neck collars are safe to use on free-roaming equids and for testing spatially-related hypotheses, we systematically reviewed studies involving

the use of GPS neck collars on free-roaming equids. We found 99 unique literature sources that met our search criteria. Our search encompassed studies from 5 continents and 7 equid species including the endangered Grevy's zebra (*Equus grevyi*), and Przewalski's horse (*E. ferus przewalskii*). Across studies, 1,057 equids were equipped with GPS neck collar transmitters for a mean study duration of 450.6 days (SD = 450.6). Of the animals collared, 41 (3.88%) sustained injuries or other negative collar effects, and 101 (9.55%) died. However, 75.6% of the injuries and 78.2% of deaths occurred in 2 studies published in 1986 and 1991. Those injuries and deaths were attributed to poor collar placement and design. None of the maladies reported after those studies were suggested to be collar-related. Thus, we conclude that the risk of collar-related injury to free-roaming equids is indeed minimal and encourage further GPS-based studies on free-roaming horses, including in the United States.

UNGULATE HERBIVORY ALTERS MORPHOLOGY, PRIMARY METABOLISM, DEFENSE CHEMISTRY EXPRESSION AND GROWTH OF REGENERATING ASPEN. Aaron C. Rhodes*, Samuel B. St. Clair; Brigham Young University, Provo, UT

Herbivory is among the most influential disturbances shaping the evolution and function of terrestrial plants. Herbivory by large ungulate herbivores can impact forest regeneration, but their long-term impacts on tree function and growth are less studied. Two separate exclosure experiments established at different time points (1989 and 2012) were used to examine how ungulate herbivory affects primary metabolism and defense chemistry expression of leaves and sapling growth rates over time. During the three year period in the first experiment, approximately 60% of aspen stems in unfenced plots showed evidence of being browsed by ungulates resulting in leaves that were only half as large, and aspen stems that were half as tall as aspen inside of fenced plots. Regenerating aspen exposed to browsing over the three-year period had 33% lower foliar starch concentrations and a nearly two-fold induction of condensed tannins compared to aspen protected from browsing. In the second experiment, aspen exposed to ungulate herbivory over a 26 year period maintained smaller leaves, had lower annual radial growth rates and were still shorter than the critical recruitment threshold of 2 meters required to escape ungulate herbivory. In contrast, average heights of aspen protected from ungulates was approaching 6 meters. Leaves browsed over the 26 year period had 53% lower starch concentrations and greater expression of condensed tannins (35%) and phenolic glycosides (50%) than protected leaves. We found no evidence in either experiment that ungulate browsing negatively impacted photosynthesis of leaves on browsed plants. It appears that increased investment in chemical defense, lower nonstructural carbohydrate concentrations and loss of leaf area, slows radial and recruitment potential of regenerating aspen.

GROUP IDENTIFICATION IN SYMPATRIC UNGULATE HERBIVORES ON THE EDWARDS PLATEAU OF TEXAS VIA FECAL SPECTROSCOPY. Douglas R. Tolleson*[1], John W. Walker[2], Nick Garza[1], Robert Moen[1], Faron Pfeiffer[3], Julie

Parsons[3]; [1]Texas A&M University, Sonora, TX, [2]Texas A&M AgriLife Research, San Angelo, TX, [3]Texas A&M University, San Angelo, TX

Ranching and hunting are two major land uses on the Edwards Plateau. Sheep (*Ovis aries*) and goats (*Capra hircus*) often share rangeland with native white-tailed deer (*Odocoileus virginianus*) and introduced species such as Axis deer (*Cervus axis*). Competition is possible among these animals. Each of these species produce morphologically-similar pelleted feces. Field identification of feces from these sympatric herbivores will facilitate management. An experiment was conducted to determine the ability of near infrared spectroscopy (NIRS) to identify fecal samples by species, age class, and sex. Fresh (< 1hr) sheep and goat fecal samples (50 ± 5g) were collected off the ground from free-ranging groups of: male, female, adult, sub-adult, and juvenile animals during late July-early August (Period 1, n = 32) and late August-early September (Period 2, n = 69) 2016. Samples were similarly collected from free-ranging white-tailed (n = 10) and Axis (n = 14) deer during the same periods. Samples were placed on ice in the field and stored at -20 C until processed for NIRS. Spectra (400-2500nm) were used to develop discriminant calibrations via 2-block partial least squares. Percent fecal nitrogen (FN) was determined using existing NIRS calibrations. Differences between groups for FN were determined using analysis of variance. Percent correct identification of groups was variably successful: collection period (98%), species (70%), age class (89%), sex (83%). Generally, FN increased (P < 0.01) from Period 1 (1.69 ± 0.05) to Period 2 (1.92 ± 0.03) but was dependent on species. For instance, FN was 1.47 ± 0.03 and 1.85 ± 0.12 (P < 0.01; sheep), 1.80 ± 0.15 and 2.08 ± 0.09 (P > 0.1; white-tailed deer) for Period 1 and 2 respectively. With larger calibration datasets, fecal NIRS could be used to provide management information for sympatric free-ranging herbivores in this savanna rangeland habitat.

Oral Technical Session:
Grazing, Wildlife and Rangeland Interactions

IMPACTS OF ALTERNATIVE RANGELAND MANAGEMENT REGIMES ON THE ECOLOGY OF GREATER PRAIRIE-CHICKENS. Lance B. McNew*[1], Virginia Winder[2], Brett K. Sandercock[3]; [1]Montana State University, Bozeman, MT, [2]Benedictine College, Atchison, KS, [3]Kansas State University, Manhattan, KS

Population declines of grassland birds over the past 30 years have corresponded with the widespread implementation of intensive rangeland management practices (IESB) that create homogenous grassland habitats. Patch-burn grazing (PBG) was tested as an alternative management technique that is ecologically similar to historically heterogeneous fire and grazing regimes, and holds promise as a rangeland management tool that may benefit grassland wildlife. We conducted a 3-year study to compare demography and space use of greater prairie-chickens, an umbrella species for tallgrass prairie conservation, on study areas managed with PBG and areas managed with IESB in the Flint Hills of Kansas. We observed multiple lines of evidence supporting conservation value of patch-burn grazing for greater prairie-chickens. Nest survival for

prairie-chickens was largely determined by vertical nesting cover, which was directly affected by rangeland management. Mean nest survival on patch-burn properties was twice as high as that on IESB properties. Our results also suggest that the interaction between fire application and stocking rates influences the space use decisions of female prairie-chickens. PBG created preferred habitats for female prairie-chickens with a 3-year fire return interval and a mosaic of burned and unburned patches, and females selected for PBG areas for both foraging and nesting. Our analysis of annual and seasonal survival and mortality risk showed that PBG practices provide habitat conditions that increase female survival during both breeding and nonbreeding seasons. Overall, populations of prairie-chickens in Kansas were not viable with current rates of population decline, and declines were predicted to be ~40% greater under IESB management compared to PBG. Our results join a growing body of evidence that rangeland management strategies that mimic historical heterogeneous fire and grazing regimes benefit native prairie wildlife.

NORTHERN BOBWHITE DENSITIES IN RELATION TO EXPERIMENTAL GRAZING REGIMES IN SOUTH TEXAS. Andrea Bruno*[1], Leonard A. Brennan[2], Micheal L. Morrison[3], Eric D. Grahmann[2], Andrew N. Tri[4], Tyler A. Campbell[5]; [1]Texas A&M University-Kingsville, Hebbronville, TX, [2]Texas A&M University-Kingsville, Kingsville, TX, [3]Texas A&M University, College Station, TX, [4]Minnesota Department of Natural Resources, Grand Rapids, MI, [5]East Foundation, San Antonio, TX

Explaining the interaction between grazing management and wildlife on rangelands requires isolating effects within a complex biophysical system. Variables such as precipitation, range site productivity, and soils are further confounded by human decision making in real world grazing operations. In South Texas, northern bobwhites (*Colinus virginianus*) commonly occur on lands where grazing and hunting are integral parts of the ranch's viability and longevity. A large-scale monitoring project was developed to assess the impact of different cattle grazing regimes on bobwhite density and vegetation structure over 4 treatment pastures (18,989 acres; continuous and rotations at medium and low stocking rates) and 3 reference sites (10,789 acres) on East Foundation lands in Jim Hogg County, Texas. Our primary objectives are to compare (1) bobwhite densities and (2) vegetation parameters both before and during-treatment on all sites, December 2014–2017. We estimated pre-grazing bobwhite density using line-transect distance sampling via helicopter between December 2014 and 2015. After 2 years of deferment, cattle were stocked on treatment sites in late December 2015. We obtained measurements of vegetation structure, forage standing crop, and grazing intensity during the autumn and summer of 2014−2016. Bobwhite density estimates pooled across the treatments areas increased by 175% from 2014 (0.20 quail per acre; 95% CI = 0.15–0.26) to 2015 (0.55; 95% CI = 0.47–0.64). Density estimates within years among the 4 treatments were similar. On the reference sites, bobwhite density increased by 35% from 2014 (0.22; 95% CI = 0.16–0.30) to 2015 (95% CI = 0.22–0.34). This study will aid managers in understanding how cattle grazing practices and vegetation structure interact to affect bobwhite densities on a population-wide scale.

VOLUNTARY CONSERVATION IN LIEU OF THE ENDANGERED SPECIES ACT: OREGON RANCHERS AND GREATER SAGE-GROUSE. Katherine Wollstein*, Emily Jane Davis; Oregon State University, Corvallis, OR

Greater sage-grouse (*Centrocercus urophasianus*) have broad public value in the American West and represent many intersecting issues affecting rangeland health and productivity. When the U.S. Fish and Wildlife Service (USFWS) determined that the species did not warrant listing under the Endangered Species Act (ESA) in 2015, the agency recognized the coordinated effort in Oregon involving private landowners, nongovernmental organizations, and state and federal agencies effectively reducing threats to the species. This effort to preclude an ESA listing of sage-grouse on Oregon's rangelands appears to follow a worldwide trend toward more participatory and flexible governance: new roles have emerged for both the state and private landowners through use of voluntary arrangements in lieu of government regulation. Through a mixed-methods critical case study of voluntary sage-grouse conservation efforts on private ranch lands in Lake County, Oregon, decision-making power and flexibility for implementers at the local-level were explored. Twenty-four in-depth, semi-structured interviews with agency staff, government officials, and ranchers whose operations include private rangelands were conducted, focusing on documenting how these actors implement sage-grouse conservation, if and how they have power and flexibility to act, and what they perceive as sources of constraints and limitations. Qualitative analysis of interviews, documentation, and public records found that while there is flexibility and a degree of autonomy at the lower levels of this governance arrangement, rancher subscription to voluntary programs is characterized by an interactive, collaborative planning process facilitated by landowner and agency leadership. This study suggests that by granting landowners and local-level agency staff flexibility in implementation of sage-grouse conservation, voluntary arrangements may offer an appealing alternative to use of the ESA on rangelands used for cattle production.

RELATIONSHIPS AMONG SPRING LIVESTOCK GRAZING, SAGE-GROUSE NEST FATE, AND CLIMATE IN SAGEBRUSH-STEPPE COMMUNITIES. Janessa C. Julson*[1], Karen Launchbaugh[1], Courtney Conway[2], Eva Strand[1], Anthony Locatelli[1]; [1]University of Idaho, Moscow, ID, [2]U.S. Geological Survey, Moscow, ID

A recent focus on sagebrush-obligate species has increased the need to understand sagebrush-steppe habitat for rangeland and wildlife management. We explored the influence of plant community attributes on nest fate of greater sage-grouse (*Centrocercus urophasianus*) in the Snake River Plain of Southern Idaho. Perennial bunchgrass height, and cover of forbs, grasses, and shrubs were examined across various ecological sites at four study locations. All study sites had an overstory of Wyoming big sagebrush (*Artemisia tridentata* subsp. *wyomingensis*) or low sagebrush (*A. arbuscula*) with a perennial bunchgrass understory and a variety of native forbs. Vegetation sampling

occurred on three plot types (nest, nest patch, and random) during the sage-grouse nesting period (i.e., mid-April to June) for three years (2014-2016). Nonmetric multidemsional scaling (NMS) and the multiple-response permutation procedure (MRPP) were used to identify patterns among the plant communities. MRPP was also used to explore the relationship between nest fate and habitat characteristics as mediated by spring livestock grazing. Preliminary analyses showed a difference in grass height between grazed and ungrazed pastures, while no difference in grass height was detected between successful and unsuccessful sage-grouse nests. Additional detail will be reported regarding variation among these attributes with respect to ecological site, yearly climatic conditions, and grazing patterns and how these characteristics relate to whether a nest was successful or not.

EFFECTS OF TIME-CONTROLLED, LIVESTOCK GRAZING ON HABITAT OF SOUTHWESTERN WILLOW FLYCATCHERS IN WEST-CENTRAL ARIZONA. Zachary Smalls*[1], Larry Howery[1], Stuart Tuttle[2], George Ruyle[1], Bob Steidl[1]; [1]University of Arizona, Tucson, AZ, [2]NRCS, Flagstaff, AZ

The southwestern willow flycatcher (*Empidonax traillii extimus*) is an endangered subspecies distributed throughout riparian forests of the southwestern United States. Many factors, including improper livestock grazing practices, have been implicated in the decline of this species. Our goal of this study is to determine the effects of time-controlled, livestock grazing on vegetation characteristics important to the habitat of southwestern willow flycatchers in west-central Arizona. Currently, livestock grazing is only allowed outside of the growing season in areas delineated as critical habitat by USFWS, and NRCS (through their Working Lands for Wildlife Initiative) is anxious to help ranch operators and landowners develop sustainable practices in these areas. Beginning in summer 2015, we began conducting vegetation surveys on two cattle ranches in west-central Arizona, measuring vegetation attributes during three sampling periods: before livestock grazing, after livestock grazing, and at the end of the growing season. We measured: 1) species composition for main herbaceous and woody plants, 2) woody canopy cover, 3) utilization of woody and herbaceous plants, 4) density of woody seedlings, and 5) volume of non-seedling woody plants. Preliminary data indicate that species composition and cover were relatively stable across most sampling periods. Time-controlled livestock grazing up to a maximum of 12 days resulted in very low utilization rates of <12% for both herbaceous and woody plants across all sampling periods. Herbivory by livestock and wildlife, and episodic precipitation events likely contributed to considerable fluctuations observed in woody seedling density.

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studies published in 1986 and 1991. Those injuries and deaths were attributed to poor collar placement and design. None of the maladies reported after those studies were suggested to be collar-related. Thus, we conclude that the risk of collar-related injury to free-roaming equids is indeed minimal and encourage further GPS-based studies on free-roaming horses, including in the United States.

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morphologically-similar pelleted feces. Field identification of feces from these sympatric herbivores will facilitate management. An experiment was conducted to determine the ability of near infrared spectroscopy (NIRS) to identify fecal samples by species, age class, and sex. Fresh (< 1hr) sheep and goat fecal samples (50 ± 5g) were collected off the ground from free-ranging groups of: male, female, adult, sub-adult, and juvenile animals during late July-early August (Period 1, n = 32) and late August-early September (Period 2, n = 69) 2016. Samples were similarly collected from free-ranging white-tailed (n = 10) and Axis (n = 14) deer during the same periods. Samples were placed on ice in the field and stored at -20 C until processed for NIRS. Spectra (400-2500nm) were used to develop discriminant calibrations via 2-block partial least squares. Percent fecal nitrogen (FN) was determined using existing NIRS calibrations. Differences between groups for FN were determined using analysis of variance. Percent correct identification of groups was variably successful: collection period (98%), species (70%), age class (89%), sex (83%). Generally, FN increased ($P < 0.01$) from Period 1 (1.69 ± 0.05) to Period 2 (1.92 ± 0.03) but was dependent on species. For instance, FN was 1.47 ± 0.03 and 1.85 ± 0.12 ($P < 0.01$; sheep), 1.80 ± 0.15 and 2.08 ± 0.09 ($P > 0.1$; white-tailed deer) for Period 1 and 2 respectively. With larger calibration datasets, fecal NIRS could be used to provide management information for sympatric free-ranging herbivores in this savanna rangeland habitat.