ORAL ABSTRACTS: 2016 SRM Annual Meeting Corpus Christi, Texas

DEVELOPING WILDLIFE HABITAT INTERPRETATIONS OF ECOLOGICAL SITES ON THE COLORADO PLATEAU.

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State and Transition Models (STM) depict changes in plant communities resulting from both ecosystem dynamics and anthropogenic perturbations. Ecological Site Descriptions (ESD) are documents that summarize the natural range of variation in plant communities for a particular type of land, and within each ESD the STM describes alternative ecological states that occur on a particular ecological site. These changes in plant community may be due to natural and/or anthropogenic stressors, and result in altered plant community composition and habitat structure. The responses of wildlife to changing habitat in terms of species composition, abundance, relative abundance, and diversity have been documented across ecosystems in the southwestern United States. In an effort to incorporate these important and repeatable patterns of wildlife response to changing habitat, we have reviewed the literature which identify specific relationships between plant communities described in ESDs and the wildlife habitat requirements of species of the Colorado Plateau. Understanding the relationship between the floral and faunal community and how changes to either can affect the other allows for the development of habitat interpretations that can be used in decision support for planning managemnt actions.

OVERVIEW OF OIL AND GAS EXPLORATION IMPACTS ON SOUTH TEXAS RANGELANDS-PAST AND PRESENT.

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Oil and gas exploration (OGE) has impacted South Texas rangelands throughout the last century. While financially benefitting the region, and positively influencing ranching enterprises, OGE has had many negative impacts on rangelands. Historic exploration lacked appreciation of negative environmental consequences, and had little regulatory oversight. As a result, legacy effects of oil and gas exploration exist across South Texas. Non-native grasses proliferated in many OGE areas because of their use in reclamation activities and propensity to invade disturbed soils. Soil degradation was also commonplace, particularly in areas where salt water spills, on-site disposal of drilling waste, or open pit drilling occurred. Areas of South Texas were subsequently characterized by the Soil Conservation Service as “oil field wasteland range sites”- a testament to the prevalence and paucity of use of these sites for any other purpose. Historic pipeline infrastructure greatly fragmented rangelands and these rights of way have been shown to serve as corridors for non-native grass spread. In the early 2000s, horizontal drilling and increased use of hydraulic fracturing ushered in a period of unprecedented OGE in South Texas, especially in the Eagle Ford Shale (EFS). Tens of thousands of new wells have been drilled and thousands of miles new pipeline infrastructure has also been constructed. Impacts of EFS exploration on rangelands have manifested in numerous ways, including the continued spread and introduction of non-native grasses to new areas, soil degradation from pipeline construction, watershed impacts, and loss, disturbance, and fragmentation of rangelands. However, because of conservation efforts of private

landowners, oil and gas operations increasingly incorporate substantial effort to minimize negative effects on rangelands, and to restore or even enhance disturbed sites using native seed sources. While oil price declines have slowed exploration substantially, managing impacts of OGE on South Texas rangelands will remain important for years to come.

TEAM TOOL: HABITAT ANALYSIS MADE SIMPLE.

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Texas Parks and Wildlife's Landscape Ecology team has developed a Google maps based application, Texas Ecosystem Analytical Mapper, (TEAM) to deliver the Ecological Mapping Systems of Texas (EMS) data to Texas citizens. The EMS data is one of the largest statewide vegetation and abiotic datasets in the United States and serves as the standard for neighboring states' landcover mapping programs. Up until the development of TEAM, these data were only available to those with expensive Geographic Information Systems software. The TEAM application is a free, **interactive mapping tool** that assist users in understanding Texas habitats and integrates vegetation data with land management and resource planning of all types. Land managers, biologists, naturalists, planners, and conservationists are able to use TEAM to view and print the EMS data in relationship to other natural feature layers such as soils, geology, hydrology and ecoregion. The application is being delivered in two phases. Phase 1 (available now) allows the user to view and print custom maps and reports of habitat data from both uploaded kml and shapefiles or areas of interest drawn within the application. Other capabilities include; exporting the map and report to a pdf and calculating the number of acres of each vegetation type within the area of interest. Phase 2 (available 2016) will add a data entry module and individual profiles for users. TEAM supports land management and conservation approaches incorporating the most current data. It also provides an avenue for community involvement in habitat understanding.

NRCS AND THE 454 SERIES.

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In much the same way as colleges and universities now provide remedial courses in math and writing, the Natural Resources Conservation Service (NRCS) must adjust its training to make up for gaps in a new employee's college curriculum or life experiences, as some college curricula neglect certain topics in favor of others and fewer new employees are coming to the NRCS with any lived experience of "the farm". Furthermore, the curriculum must account for the inevitability of employee turnover, as experienced employees retire or leave the NRCS for other employment and are replaced by new employees. In April, 2015, a team of NRCS subject matter experts (SME) met to conduct an in-depth Rangeland curriculum review. During the three-day review meeting, the participants clarified gaps, pinpointed training challenges and needs, and proposed solutions to existing problems with the goal of creating a better prepared, more knowledgeable, and more successful workforce. This presentation summarizes the participants' findings and recommendations.

ADAPTIVE GRAZING STRATEGIES: POINTS OF CONSENSUS; POINTS OF CONTENTION; POINTS TO ACHIEVE?

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Since the Society was founded in 1948, grazing management to achieve vegetation and animal productivity objectives has been a major emphasis of research. Early efforts generally concentrated on using plant physiological cues to determine acceptable levels of defoliation and deferment to maintain plant vigor and encourage recruitment of desired species. Many studies were performed on landscape scales but often lacked replication or adequate controls. Others were performed at individual plant scales. Much valuable information resulted regarding physiological responses to defoliation, indicators of plant recovery, and how plants and plant communities respond to defoliation timing, intensity and opportunities for regrowth. Many of these insights are points on which most scientists and managers still agree. In the 1980s through 2000s, interest increased regarding more intensive management of grazing using more paddocks/herd, higher animal densities and more frequent moves. These studies were often replicated, but livestock movements were generally implemented in a rigid, calendar-based manner, possibly without adequately accounting for plant physiological needs for recovery following defoliation. In a 2008 review of the literature, Briske and colleagues found that the preponderance of scientific studies regarding this type of management showed no consistent advantages for livestock or vegetation productivity compared to continuous grazing despite the fact that many grazing managers are using some form or multi-paddock grazing. Yet the points on which we agree are many, as are the questions to which we do not have answers. In 2011, they asserted that adaptive management, not a particular grazing “system,” determined the success of any grazing approach, and called for a collaborative approach between scientists and grazing managers. This presentation explores the points of consensus, the basis for that consensus, and introduces some possible scientific questions and approaches on which scientists and managers might collaborate.

EXOTIC GRASSES FOR WILDLIFE IN TEXAS AND NORTHERN MEXICO, ARE THEY AS BAD AS WE THINK?

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Northern Mexico includes three major ecosystems, the Tamaulipan Biotic Province, the Chiuahuan Desert, and the Sonoran Desert. Texas shares the Tamaulipan Biotic Province and the Chiuahuan Desert. Production systems in both countries have experienced important changes over the years, with game wildlife becoming an increasingly important part of the ranching industry because its economic value. Range management practices have been adapted to meet habitat requirements for game species in addition cattle requirements. Range management for multiple species is more complex. Adaptive management needs to be used to guarantee the integrity of the plant communities and optimize productivity and economic output of ranches.

SUSTAINABLE LIVESTOCK PRODUCTION IN SUB-ARCTIC ALASKA: PLANT AND SOIL RESPONSES TO SIMULATED INTENSIVE GRAZING.

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Managing a robust pasture ecosystem and optimizing available forage under sub-arctic conditions in interior Alaska is a challenge. The region is characterized by a short growing season, slow residue decomposition rates and undeveloped soils that are vulnerable to compaction and erosion. Current unmanaged grazing has resulted in a heterogeneous pattern of use; with animal feeding preferences creating patches of both over- and under-utilization, and degradation. The goal of this research was to evaluate the response of circumpolar pastures to an intensively managed rotational grazing (IMRG) regime and examine the role of herbivory, trampling, and dung/urine deposition on pasture productivity and ecosystem services. To evaluate the impacts of IMRG, a full factorial experiment of simulated trampling, muskox (*Ovibos moschatus*) dung/urine deposition, and forage clipping, mimicking IMRG timing and intensity, was conducted at the Robert G. White Large Animal Research Station, University of Alaska, Fairbanks. The simulations were conducted on 96-1 m2 plots in two established pastures with different soil types, over the 2014 and 2015 grazing seasons. Changes in soil biota, physical soil characteristics, plant biomass, and plant community were measured from one and two years of treatment applications to evaluate the potential suitability of IMRG for livestock farms in interior Alaska. Preliminary results of plant biomass have shown that the treatments have had a marked impact on biomass productivity (p<0.001). Data on microbial activity, soil organic matter content, and changes in plant species composition in response to simulated grazing treatments will be presented. This research provides a twofold benefit; it evaluates site-specific responses to IMRG and provides insight into the role of grazing disturbance mechanisms on sub-arctic soil and plant health.

BEAVER AND STREAM CONDITION AND TREND EXAMPLES FROM THE UINTA MOUNTAINS AND TAVAPUTS PLATEAU.

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Beaver are an inherent, controlling factor in stream channel morphology and stream-side vegetation dynamics. However, beaver driven conditions are sometimes not recognized in evaluations of stream channel and riparian community condition. Beaver driven conditions can be interpreted as being something other than desirable. However, beaver are commonly viewed as desirable components of riparian systems. The gap in attitudes toward beaver and accepting stream conditions driven by beaver indicates assessments of stream channels and riparian conditions are sometimes made without recognizing conditions controlled by beaver. Turbid water is a common feature of beaver ponds. Failed beaver dams with exposed mud-flats, down-cut channels within mud-flats, and scouring below dams are all factors inherent to beaver driven systems. Where beaver dam density is high, these factors can dominate sizable reaches of streams. These features are easily associated with beaver before and shortly after dam-failure. However, in time they become less conspicuous, and are more likely to be

attributed to other causes including livestock. Inclusion of beaver-dynamics in riparian evaluations is essential to drafting realistic goals and desired conditions. Evaluations of riparian condition and trend need to include beaver dam density, frequency of dam failures, and other features of beaver activity. Reaches of stream with relatively high density of beaver dams should not be evaluated with the same criteria as reaches with no or little beaver activity. Unless beaver driven features are recognized in assessments of riparian function, condition, and trend, assessments will be misleading, and they likely lead to management actions that will not bring about expected or desired change. Rate of recovery of vegetation in drained beaver ponds might be used as an indicator for evaluating function in relation to livestock grazing.

OAKS AND PRAIRIES JOINT VENTURE STRATEGIC GRASSLAND BIRD HABITAT CONSERVATION IN TEXAS AND OKLAHOMA.

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The Oaks and Prairies Joint Venture partnership has undertaken an ambitious effort to address declining grassland bird populations (e.g. Northern Bobwhite, Loggerhead Shrike, Eastern Meadowlark) in the central grasslands of Texas and Oklahoma. This effort includes development of shared biological objectives, landscape conservation design, focused conservation delivery, and intensive habitat and population monitoring. In addition to the existing partner led conservation delivery programs, the primary means of providing focused conservation delivery for this effort has been through the Grassland Restoration Incentive Program (GRIP) which provides private landowners with financial support for implementing costly habitat restoration practices on their property. Since the OPJV implemented the program 2 years ago, over 45,000 acres of grassland bird habitat have been improved on private working lands in Texas. The practices employed include brush management, prescribed fire, native grass reseeding, and prescribed grazing. 32,000 acres of GRIP habitat improvements have been through the adoption of wildlife friendly grazing practices. In return for adopting these practices, which often involve reducing stocking rates and in some cases destocking for a period of time, landowners have received as much as $25/aum from the program offsetting the opportunity costs of choosing not to graze a parcel. With its ability to assist landowners who choose to manage their property in a way that also provides for the needs of resident wildlife, the OPJV considers GRIP to be a mutually beneficial program for all involved.

APPLICATION OF VGS IN RANGELAND EXTENSION EDUCATION.

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I have been using the Vegetation GIS Data System (VGS) in my role as a University of Arizona rangeland extension specialist/research scientist for eight years. We use VGS to collect annual rangeland monitoring data on the V Bar V Ranch Agricultural Experiment Station, which operates on a US Forest Service allotment, as well as in monitoring efforts on several other public land ranches in northern

Arizona. These collaborative efforts provide many hands-on extension education opportunities. For instance, the ability to save data and view a report in the field immediately upon completion of reading a key area facilitates onsite discussion of results with participants. For sites read in the past, comparisons to previous data are readily obtained. These features provide for informed discussions concerning management, cause and effect, and future planning. Such discussions with producers or land managers typically occur days if not months after observations are collected and while still useful, are not as effective as those occurring in "real-time". Additionally, we have collected research data on projects ranging from an evaluation of the effects of grazing on soil carbon and nitrogen in two climate/vegetation types to comparing different data collection techniques to inform landscape scale biophysical plant growth models. Early extension efforts using VGS largely centered on the latter research project listed and involved approximately 200 local high school students over a three year period. These students were attracted to the technology of ruggedized tablet computers, easily learned how to use VGS, and stayed engaged in the data collection process. Students also seemed to learn and remember plants more quickly than when we were only working on plant identification, or when we collected data with pen and paper on a clipboard. VGS has proven to be an effective teaching tool for a variety of learners and applications.

QUANTIFYING SUSTAINABILITY OF GOODS AND SERVICES FROM RANGELANDS: A DATA DRIVEN APPROACH.

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Rangelands encompass approximately 662 million acres in the coterminous US and their extensive area and diverse character create a large array of ecosystem goods and services (EGS). Ecosystem goods and services are supported by rangeland ecological processes while human systems interact with rangelands ecosystems through a variety of social processes. The Sustainable Rangelands Roundtable has developed a series of 64 indicators of rangeland sustainability (http://sustainablerangelands.org/pdf/SM56.pdf) which are meant to identify where the ability of rangelands to sustainably produce desired EGS has been, or may become, compromised. The exceptional variety and value of EGS derived from rangelands obviate the need for periodically evaluating threats to sustainability of these entities. Methods to evaluate the sustainability of EGS, however, are not widely agreed upon or institutionalized. Here, a potential method for quantifying risks to sustainability is presented. This project has three objectives: (1) Identify threats to rangeland sustainability and develop quantitative models (2) Increase awareness of methods for evaluating sustainability (3) Create a spatially explicit database used in the analysis and offer these data to other researchers. Nine data elements linked to rangeland sustainability are evaluated using principle components analysis and unsupervised classification. Results clearly indicate that those counties with a greater abundance of exotic species, declining rangeland base, or high degree of fragmentation are at greater risk of reduced production and maintenance of EGS.

PROJECTIONS SUGGEST UNCERTAIN AND POSSIBLY PERILOUS FUTURE FOR U.S. CATTLE OPERATIONS.

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Anticipation of changing conditions and the identification of sources of vulnerability is critical to selecting effective adaptation measures. Rangeland changes are not expected to be uniform, thus appropriate actions will not be universal. We examined the vulnerability of cattle production on U.S. rangelands to climate change effects by estimating changes in forage quantity, vegetation type trajectory, heat stress, and forage variability. Our measure of vulnerability assumed livestock operations were sustainable under climate conditions of recent experience, thereby providing a locally derived estimate of change. Projections to 2100 were translated into vulnerability as departure from the current baseline (2001-2010). Forage quantity was taken from a biogeochemical cycling model of net primary productivity (NPP) and was projected to increase in northerly regions potentially benefiting cattle production. The trajectory of vegetation type towards or away from preferred cattle forage was estimated using the dynamic vegetation model, MC2. Vegetation types were projected to move towards more grass types overall, but there was considerable heterogeneity across the rangeland extent and within regions. Heat stress was estimated as the number of days per year where the thermal neutral zone for beef cattle would be exceeded. Projected impacts were consistently negative across multiple elements in southerly and western rangeland regions providing strong evidence for declining production. In northern and interior regions, benefits of increased NPP or inertia towards grassier vegetation types were mostly tempered by negative impacts from increasing heat stress and forage variability. Southwestern rangelands and cattle operations experienced the greatest problems but disagreement among elements as to the direction of change indicates that reliance on projections for a single element will limit our ability to anticipate impacts and sustain livestock production obviating the need for integrated impact studies such as the current work.

FORB ECOLOGY EMPHASIZES THE NEED FOR UNDERSTANDING RANGELAND BIODIVERSITY AND ITS ROLE IN WILDLIFE MANAGEMENT.

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Successful management for wildlife habitat on unhealthy rangelands requires the improvement of biodiversity and restoring ecosystem structure and function. Higher biodiversity influences the presence of a suite of species that contribute to a continuum of resources across trophic levels providing stability in the ecosystem. Understanding the need to improve biodiversity to promote wildlife habitat, multiple restoration treatments in desert grasslands on the O2 Ranch in Brewster and Presidio Counties, Texas have been implemented over the past decade. In 2014, twelve Modified-Whittaker nested sampling plots were established to monitor plant biodiversity within treatment areas. Sampling occurred in areas treated with Spike only and areas treated with Spike followed by prescribed fire. Forb diversity was significantly higher in areas of Spike and prescribed fire ($P < 0.001$). Within monitoring areas, a little-known forb species was rediscovered (*Plateilema palmeri*) that has remained unobserved in the US since 1929. The presence of this species has prompted further biological study of its ecological role and microhabitat. *Plateilema palmeri* appears to have importance to wildlife and invertebrate populations within these desert grasslands, thus contributing to trophism and overall ecological health. To better understand this species habitat and range, a species distribution model (SDM) has been created. SDMs

are valuable tools in assisting managers towards decisions regarding habitat selection and management for plant and wildlife species. In conjunction with inventory and monitoring data, SDMs may help to identify target areas for restoration of wildlife habitats. This systems approach in understanding how species are distributed throughout the general landscape, or in microhabitats, can assist managers in working together with ecosystem processes and ecological factors towards enhancing biodiversity and promoting ecological stewardship. The O2 Ranch will use this SDM for *P. palmeri* in management decisions regarding further restoration for grazing areas and wildlife habitat management.

FERMENTATION KINETIC OF MEDUSAHEAD AND PARTICLE SIZE REDUCTION CONTRIBUTE TO EXPLAIN LOW INTAKE AND PALATABILITY.

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It has been proposed that the high silica content of medusahead (*Taeniatherum caput-medusae* ssp. *asperum*) reduces digestibility and thus intake by ruminants, making this weed a successful competitor in grazed plant communities of the western US. The goals of this study were to measure the final digestibility and digestibility kinetics of medusahead relative to more palatable forages (alfalfa and tall fescue hay) at (1) different phenological stages (from late vegetative to beginning of senescence and thatch) and (2) at different particle sizes (1, 5, 10, and 20 mm). Samples were incubated at 2, 4, 6, 8, 12, 18, 24, 36, 48, and 72 h in 2 replicates using an *in vitro* gas production method. The experimental design was a factorial with replicates as the repeated measure. Silica content was greater in medusahead at different phenological stages (6.4 to 10.5% range) than in tall fescue (4.1%) or alfalfa hay (0.9%). Digestibility of medusahead at different phenological stages, except thatch (64.8 to 70.5% range), was similar ($P > 0.05$) to that of tall fescue hay (67.0%) and greater ($P < 0.05$) than digestibility of alfalfa hay (53.3%). Medusahead thatch had the lowest digestibility (45.9%; $P < 0.05$). Fermentation kinetics showed medusahead with similar fermentation rates to tall fescue hay but lower fermentation rates than those of alfalfa ($P < 0.05$). Greater particle sizes reduced digestibility and fermentation kinetics of medusahead to a greater extent than in the rest of the forages tested ($P < 0.05$). Thus, fermentation kinetics and particle size reduction, instead of just digestibility values, explain the low intake and palatability of medusahead at phenological stages other than thatch. The high silica content of the weed likely decreases the mechanical and enzymatic breakdown of the plant material in the rumen, decreasing passage rate and prolonging fill effects in the rumen.

DIFFERENTIATION BETWEEN DIFFERENT RANGELAND SITES IN SEMI ARID AREAS OF SUDAN USING REMOTE SENSING TECHNIQUES (CASE STUDY: NORTH KORDOFAN STATE).

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Rangelands in Sudan constitute the main land use system in arid and semi-arid areas, that provides good sources for feeding huge numbers of animals in addition to their environmental and social importance,

therefore, these areas are considered economically and environmentally important for the pastoral sector in the Sudan. This study aims to differentiate between different rangelands sites in semi-arid areas of Sudan using RS for management purposes. The methodology based on using remote sensing techniques including principal component analysis to differentiate between different rangeland sites as indicated by soil types and vegetation patterns for monitoring and assessment purposes. Characteristics of these rangeland sites were used to understand soil/plant/landform relationships and their response to ecological and management considerations. Three rangeland sites were identified in the study area as *gardud*, sand sheet and sand dune. Principal Component Analysis (PCA) was used to reduce the number of factors needed to distinguish between rangeland sites where new data set including the most useful spectral information for differentiation to run image processing and automated classification. The selected types of data were used (two vegetation indices, topographic data and vegetation surface reflectance within the three bands of MODIS data).Un-supervised classifications were applied to the new dataset. The method categorized the image into three classes for the two years 2005 and 2011. Analysis with PCA indicated that there is a relatively high correspondence between vegetation and soil of the total variance in the data set. The results showed that the use of the principal component analysis with the selected variables showed high differences that can be used for differentiation. The results also showed that the use of PCA to make unsupervised classification with these variables, cross-checked with ground points enabled identification of main vegetation groups within the sites, which is a more refined reference for monitoring.

SILVER SAGEBRUSH REGROWTH AND PLANT COMMUNITY RECOVERY FOLLOWING FIRE: IMPLICATIONS FOR GREATER SAGE-GROUSE IN CANADA.

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Greater sage-grouse (*Centrocercus urophasianus*), a critically endangered bird in Canada, inhabit plant communities with abundant silver sagebrush (*Artemisia cana*) in Alberta's Dry Mixedgrass natural subregion. In contrast, the dominant shrub in the core of sage-grouse range is big sagebrush (*Artemisia tridentata*). Wildfire may threaten sage-grouse due to habitat loss, slow recovery of sagebrush, and exotic species invasion after burning, which can alter fire regimes. However, silver sagebrush plant communities may respond differently than those of big sagebrush because the former shrub may better recover following fire and these communities are perhaps less prone to invasion of annual grasses. This study used an accidental wildfire in important sage-grouse habitat in Alberta, Canada to examine how silver sagebrush and sagebrush plant communities recover following a late-season fire. Measured variables included shrub density and height, as well as plant community composition and productivity. Within 4-5 weeks of burning and following favourable rainfall, silver sagebrush readily recovered to similar pre-burn densities, but remained reduced in stature. Sagebrush grew markedly two growing seasons post-burning, and plant community productivity also recovered. Perennial grasses readily re-established but fire markedly increased bare ground, reduced litter, and eliminated some groundcover species. Despite this there was no evidence of invasive annual grasses in burned communities. Results indicate that silver sagebrush readily re-establish following fire via suckering and these solonetzic plant communities are largely resilient to fire and annual grass invasion, suggesting that this area may return

to functional sage-grouse habitat in a relatively short period. Questions remain regarding how frequent fire and post-fire grazing management and drought may further influence sagebrush recovery.

INTRODUCTION TO THERMAL ECOLOGY.

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Temperature is one of the most basic factors that influences the distribution, survival, and reproduction of organisms. Despite this, very little research has been conducted on the relationships between vertebrates and thermal variation at relevant landscape scales. The limited data that do exist demonstrate that landscapes are thermally heterogeneous, providing organisms with choices for selection. Further, organisms that have been evaluated have been shown to select for temperature variation which influences survival at various life history stages. Techniques to capture thermal heterogeneity in rangelands and examine potential animal selection will be discussed with implications for vegetation management and species persistence.

NUTRIENTS AND SECONDARY COMPOUNDS INFLUENCE TREMBLING ASPEN (POPULUS TREMULOIDES) INTAKE BY SHEEP.

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Browsing by ungulates is one cause for aspen decline in western North America. The goal of this study was to explore the influence of plant chemicals (protein, aspen bark, phenolic glycosides [PG] and condensed tannins) on aspen intake and preference by sheep. Thirty two lambs were penned individually and randomly assigned to 4 molasses-based supplements (n=8) in a factorial design with repeated measures during three trials of 10 d each: (1) High-protein (HP-40% canola meal; 20% CP), (2) Condensed tannins (CT-6% quebracho tannins), (3) aspen bark (AB-25% aspen bark) and (4) Control (100% molasses). Supplements were fed at a rate of 1.42 Mcal of digestible energy/day from 0700 to 0900 and then lambs were offered freshly cut aspen leaves collected from aspen stands with high (13.2%; Trial 1) and low (7.9%; Trial 3) PG concentrations. During Trial 2, lambs were offered aspen leaves (33.8% PG), Utah pea, and smooth bromegrass. Refusals were collected after 2 h and a basal diet of tall fescue hay was offered until 1800. Aspen intake was greater when leaves had low concentrations of PG (5-7 vs. 2-3 g DM/Kg metabolic body weight [MBW]; $P < 0.05$). Supplements HP and CT led to higher intakes of aspen in Trials 2 and 3 (4 to 7 g/Kg MBW range), whereas supplement AB promoted the lowest intake of aspen (2 g/Kg MBW) during Trial 1 ($P < 0.05$). In summary, chemical defenses like PG in aspen bark and leaves depressed aspen intake by sheep but HP and CT had the opposite effect likely due to the beneficial effects of protein (e.g., rumen degradable protein, escape protein from CT-protein complexes) on detoxification processes.

AUTUMN AND WINTER DYNAMICS OF WHITE-TAILED DEER BROWSE NUTRITIVE VALUES IN THE SOUTHERN CROSS TIMBERS.

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White-tailed deer (*Odocoileus virginianus*) are economically important to rangeland operations in Texas and Oklahoma. Deer herd health, production and survival rates decline when population size exceeds the available forage. During winter, when rainfall is scarce and temperatures limit plant growth, white-tailed deer nutrition is limited and forage availability decreases drastically. During these times, white-tailed deer winter diets are mainly comprised of browse species because herbaceous production decreases as winter progresses. The objective of this study was to determine the influence of winter progression on nitrogen (N), neutral and acid detergent fiber (NDF and ADF) concentration and in vitro organic matter disappearance (IVOMD; free-range white-tailed deer rumen liquid) of six browse species of moderate to high forage importance in the Cross Timbers. Browse samples were collected during pre-frost, mid-winter, and late winter from four (replications) properties in north-central Texas over 2 years. Years did not affect (P>0.05) results. There was an interaction ($P \leq 0.05$) between browse species and season for all forage values. Nitrogen, a desirable nutrient, decreased ($P \leq 0.05$) as winter progressed while IVOMD also decreased ($P \leq 0.05$) as fiber increased with winter progression in five of the six browse species. Texas oak (*Quercus buckleyi*) kept some of its leaves and nutritive value through early but not late winter. Live oak (*Q. virginiana*) kept its leaves throughout winter and maintained a mean 1.33% N with lowest ($P \leq 0.05$) fiber levels and the highest (52.7%; $P \leq 0.05$) IVOMD in late winter. Results confirm that nutritive value of browse, especially N and fiber, decreases in most but not all browse after the first freeze when most woody species shed leaves. It also emphasizes the need for plant biodiversity in habitat that supports adequate year-round white-tailed deer nutrition.

INFLUENCE OF EXPERIENCE AND AVAILABILITY OF DIFFERENT FORAGES ON MEDUSAHEAD INTAKE BY SHEEP.

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The goal of this study was to test the effects of early experience at grazing medusahead and the availability of forage alternatives on intake of medusahead by sheep. The study involved two phases of 10 days each. During the first phase animals were penned individually in a 2x2 factorial design with early experience at eating medusahead (yes, no) and availability of alfalfa hay (yes, no) as the main factors. All animals were fed freshly harvested medusahead from 1000-1300 and half of the animals received alfalfa hay (0.3% BW). All groups had a basal diet of tall fescue hay. After the pen phase, sheep were clustered in 10 groups (n=5 early experience; n=5 experience gained during phase 1) of 3 sheep each and moved to plots in medusahead-infested rangeland. Grazing events were recorded at five minute intervals from 0800-1000 and 1600-1700. In phase 1, medusahead represented 3.9% of the yearlings' diet and a cyclic pattern of medusahead intake was detected in a day effect ($P < 0.0001$). The highest intake values ($P <$ 0.05) occurred on days 1 and 10 and an intermediate peak of medusahead intake was observed on day 6

($P > 0.05$). In phase 2, the percentage of grazing events recorded on medusahead was almost nil for all animals (0.64 %). Yearlings spent more time eating forbs than grasses until day 7 (57.6 vs. 41.4 %), when the pattern reversed until the end of the phase (61.3 vs. 37.0 %). In summary, intake of medusahead was cyclic and not influenced by the animals' early experiences with the weed or by the availability of forage alternatives.

ENHANCING NATURAL RESOURCE MANAGEMENT OF PASTURES AND RANGELANDS WITH REMOTE SENSING TECHNOLOGY (FULL SYMPOSIUM).

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Technological advancements to miniaturize aircraft and sensors have allowed for the use of Unmanned Aircraft Systems (UAS) for natural resource management. Ground-based sensors have been used in precision farming and research applications for many years. Recent advances making UAS less expensive, along with regulatory changes, have increased opportunities for the use of UAS to enhance natural resource management. Areas of development include precision management and research, including phenotyping, water and nutrient mapping, herbage mass measures, nutritive value measures, weed and brush encroachment, and animal censusing. This symposium focuses on enhancing natural resource management with UAS technology in both introduced and native rangeland systems.

DECISION-SUPPORT FOR SITE-SPECIFIC RANGELAND MANAGEMENT: MANAGING FOR MULTIPLE ECOSYSTEM SERVICES.

Theresa Becchetti*[1], Valerie Eviner[2], Sheila Barry[3], Morgan Doran[4], Josh Davy[5], John Harper[6], Mel George[2], Roger Ingram[7], Royce Larsen[8], David Lile[9], Carrissa Rivers[10], Kenneth W. Tate[11], David Lewis[12]

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Effective rangeland management and restoration are limited by our inability to account for site-specific effects of management on multiple goals. California's rangelands cover 57% of the state, and are the target of local, state and national funding to support conservation of species and ecosystem services. However, over 80% of conservation projects fail due to lack of site-specific recommendations. This project is compiling data from many of the UC/UCCE research projects on ecosystem services, along with data from thousands of management trials across California's grasslands, oak woodlands, and riparian systems to determine how environment by management interactions affect the provisioning of multiple ecosystem services. A searchable database of management effects on multiple ecosystem services has been developed. The searchable database provides land managers with knowledge of

successes and failures of management projects in similar sites, and with similar goals. We are analyzing case studies to provide site-specific recommendations of which goals are most feasible, and which management approaches are most promising to achieve those goals. A focus on the impacts of drought on ecosystem services, and how these vary by site conditions (e.g. soil type, aspect) and management (e.g. burning, grazing, etc.) has been a priority with California's on-going drought. This project will improve our site-specific management for multiple ecosystem services by compiling thousands of management trials and research studies, resulting in: (1) Improved tools for science-based decision making and (2) Improve science-based regulatory and incentive programs. California programs such as climate change mitigation measures, and water quality programs will benefit from the synthesis of these case studies, and we have actively worked with California Climate and Agriculture Network on developing educational programs for legislators and land managers on the potential for management to improve ecosystem services.

AN ASSESSMENT OF LESSER PRAIRIE-CHICKEN NEST MICROCLIMATE AND NEST SURVIVAL AMONG THREE ECOREGIONS.

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Nest microclimate and concealment are critical components to the development of avian embryos; however, the correlation between microclimate and nest survival are unclear, especially since trade-offs exists between protecting the nest from predators while maintaining suitable microclimate. To address this question for Lesser Prairie-Chickens, we placed data loggers adjacent to nests to quantify temperature and aridity distribution functions, 2010–2014. We developed a suite of *a priori* models using the nest survival model in Program MARK to estimate nest survival probabilities. We monitored 105 nests among three ecoregions and our results indicate the southern distribution was hotter and drier during incubation compared to the northern distributions, there was considerable inter-annual variability in nest microclimate within ecoregions, the percentage of microclimate recordings where temperature was > 34°C and aridity was < -23mmHG during the day explained nest survival to the greatest extent, and microclimate received more model support for nest survival compared to visual obstruction. Our results suggest conservation of the species would benefit from the identification of thermal landscapes that promote cooler, more humid conditions during nest incubation.

HOME ON THE RANGE: K-12 RANGELAND EDUCATION CURRICULUM.

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The *Home on the Range* workshops have been presented to over 1,000 elementary school teachers reaching a minimum of 22,000 students per year in all 20 regions of the state of Texas. These workshops are based on *Rangelands: A Conservation Education Guide,* created for Welder Wildlife Foundation by

Dr. Sandra Johnson, an experienced educator, and Jaime Winans, a Wildlife Biologist. Come take part in a workshop to help you learn what teachers and students need and how to meet those needs. Participate in activities including models, games, role-playing, and field activities that demonstrate best practices in education and proven ways to engage and teach both teachers and students about many aspects of rangelands. Activities include *Small Scale Rangelands, My Home, My Habitat, Grazers and Browsers, Grow, Grass Grow!*, and other activities focused on rangelands. Activities fulfill Texas state curriculum requirements including concepts such as habitat, adaptations, structures and functions, interactions in an ecosystem, and more.

CAMEL GRAZING PREFERENCES FOR HERBACEOUS VEGETATION AND TREES AT KALEMANDO DISTRICT, NORTH DARFUR STATE, SUDAN.

mohammed Abdelkreim*[1], Babo Fadalla[2], Abdelrahim Mansoor[3]

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This study was conducted at Kalemando, North Darfur State, Sudan. The objective was to investigate diet selection by camels and develop plant relative preference indices. The Parker loop method was used to determine range botanical composition and the bite count technique was used to assess diet botanical composition. A questionnaire was also developed to capture pastoralists' perceptions on range plant preferences. We found that the herbaceous plants most preferred by camels in the southern site were *Ipomoea sinesisvar (RPI=65.05) and Corchorus olitorius (RPI=29.14). Eragrostis diplachnoides* was desirable (RPI=0.70) while the rest of the plants were undesirable (RPI <0.70). In the northern site plants most preferred were *Justicia kotschyi, Tephrosia uniflora*, *Tripogon minmus*, *Aristida mutabilis* and *Echinocloa colonum*. Browse trees preferred by camels were *Acacia mellifera* (37.28%), *Acacia tortils* (16.66%), *Permina resinosa (*9.75%) *and Boscia sengalensis* (7.08%). For rangelands improvement in these area with plants preferred by the camel, such as, *Ipomoea sinensis, Justicia kotschyi, Corchorus olitorius, Echinochloa colona, Aristida abscensionis*, *Tephrosia uniflora*, *Dactyloctenium aegyptium, Oxygonum atriplicifolium and Eragrostis diplachnoides,* as well as *Acacia mellifera* should be considered.

DROUGHT MANAGEMENT EDUCATION IS STILL NEEDED ON GREAT PLAINS RANCHES.

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Droughts are a normal occurrence in the Great Plains and negatively impact ranching operations' financial, environmental, and biological resources. We conducted a systematic sample survey of 954 cattle ranching operations in the western two-thirds of Nebraska and South Dakota in 2014 to evaluate ranchers' opinions and management decisions related to droughts that occurred in 2012 through 2014. The survey had a response rate of 44%. Respondents indicated that droughts were extremely to

moderately harmful to rangeland health (70%), animal production (65%), cash reserves (65%), and value of the ranch operation (37%). During the widespread drought of 2012, producers used multiple drought management strategies to cope with low forage production by feeding purchased hay or supplements (64%), feeding own hay stockpiles (86%), grazing fall or winter pastures earlier than planned (51%), and grazing cover crops or crop residues (54%). Producers also delayed spring turnout (57%), weaned calves earlier (55%), sold cull animals earlier than usual (63%), and 48% reduced breeding animal numbers by less than 25%. Although ranchers used many strategies to deal with low forage supplies, only 28% thought that financial outcomes of their management decisions during drought were predictable and controllable, whereas 61% of the respondents indicated that the financial outcomes were unpredictable and/or uncontrollable and 11% were uncertain as to the outcome. It is apparent from these results that effective outreach regarding drought preparedness could be beneficial to producers preparing for drought conditions. These programs potentially include holistic approaches to drought planning including alternatives to minimize financial impacts, i.e. trigger dates to implement management decisions, tools to access weather and market forecasts, using conservative carrying capacity estimates, and flexible livestock options such as diversified enterprises, e.g. yearling backgrounding.

SEED PRODUCTION, SIZE AND COMPETITION IN BLUEBUNCH WHEATGRASS PSEUDOROEGNERIA SPICATA.

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Predicting the effects of climate change on dominant plant species is a pressing challenge for the management and restoration of ecosystems. Knowing how a population has responded historically to climate variability may be a valuable indicator of responses to future climate change. A historical data set showing changes in plant community structure gives us a unique opportunity to examine the link between climate and demography for several plant species. When compared with climate records from that region, we can examine the relationship between climate variability and recruitment, growth and survival. The Adler Lab Group uses this information to fit integral projection modes (IPMs). However, because the historical data sets do not contain information on seed production, the current models assume a linear relationship between plant size and seed production. This project was designed to improve upon the IPMs currently used by the Adler Lab Group by directly observing the relationship between individual size and reproductive output, in the absence and presence of competition. The focus of the project was bluebunch wheatgrass *Pseudoroegneria spicata,* an abundant, perennial grass species. In the field, 60 plants of various sizes were randomly selected and competition was removed around 30 individuals; growth and seed production were monitored for two years. The resulting data was analyzed using regression models to describe the relationship between seeds, size, and competition. Large plants are more likely to flower than plants in the small or medium size classes, but any plant that flowers, regardless of size class, will produce a comparable number of seeds. Plants were less likely to flower in the absence of competition (a possible consequence of non-resource environmental effects. As result of this study, the IPMs used by the Adler Lab Group will include important demographic information for the bunchgrass *Pseudoroegneria spicata.*

LIVESTOCK TRACKS TRANSFORM RESOURCE DISTRIBUTION ON TERRACETTE LANDSCAPES OF THE LOESS PLATEAU.

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Striking networks of livestock tracks, or terracettes, molded to the contours are a common feature on hilly rangelands of the semi-arid Loess Plateau that is one of the regions with the most severe soil erosion in the world. The formation of livestock tracks results in modified micro-topography and strong patterns in spatial distribution of vegetation and soil physical properties, water and nutrients, which may have significant implications to the hydrological and biogeochemical processes. We investigated the spatial pattern of the topo-edaphic, hydrological, biogeochemical, and biological attributes of these terracette landscapes and explored their potential implications to ecosystem functions. The results showed strong spatial heterogeneity in topo-edaphic and biological structure of these landscapes organized with three segments of a basic landscape unit - track, shoulder and inter-slope. The above- and below-ground biomass and soil nutrients concentrated in the shoulder segment forming a "band of fertility". The network of livestock tracks likely reduced runoff and surface erosion by intercepting runoff and facilitate infiltration while posing little risk of increasing shallow slope failures given the structure of Loess soil. There is likely a positive feedback loop for maintaining the structure of terracette landscapes - trampling by goats maintains the tracks which lead to spatial heterogeneity in biophysical structure and processes; the network of tracks enabled the goats to travel and graze in ways that reduce energy expenditure and increase foraging efficiency, which leads to strongly preferential use of the tracks by the goats. Functional differences in regulating water runoff and soil erosion, forage production, and soil carbon storage between terracette landscapes and landscapes without networks of livestock tracks can have significant implications to land use policies and practices aiming at soil and water conservation and socio-ecological sustainability of the Loess Plateau, and warrant further investigations.

AN INTEGRATED RANGELAND AND PASTURELAND ASSESSMENT AND MANAGEMENT OPTIMIZATION APPROACH.

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In the USA, rangeland health assessments follow Interpreting Indicators of Rangeland Health (IIRH) protocols, while pasturelands are usually assessed using the Pasture Condition Score (PCS) system. The IIRH method provides a way of detecting changes in ecological attributes relative to a site's ecological potential while PCS informs managers about the utility of an area for livestock production or factors that could be keeping the area from operating at its full or optimized productive potential. There is a need for an improved grazingland assessment tool that merges the relevant elements of both the rangeland and pastureland assessment methods while taking into account the differing ecosystem attributes and management objectives of the grazinglands where these methods are usually applied. We use IIRH and PCS data collected at two locations in the Northern Great Plains of the USA to describe our proposed approach and demonstrate its usefulness. We present an improved grazingland assessment protocol

that is applicable to range and pasturelands and allows evaluators to assess site conditions, and to make interpretations regarding management based on site-specific attributes that can potentially optimize the ecological potential and livestock carrying capacity of a site.

EVALUATION OF TECHNIQUES FOR RESTORATION OF NATIVE PLANTS TO NEW PIPELINE RIGHT OF WAYS..

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Pipeline development in association with oil and gas exploration has many effects on rangelands in South Texas. Soil disturbance and loss of vegetation along pipelines right of ways is a concern of many landowners. From 2012-2015 we studied the effectiveness of standard planting techniques and the performance of various commercially available locally adapted native plant seed sources for use in pipeline right of way restoration. Two experimental plantings were conducted on two different ranches following pipeline installation within the Eagle Ford Shale. The Eagle Ford Shale oil and gas play is a geologic formation roughly 400 miles long by 50 miles wide that stretches from east Texas across South Texas into Mexico. At one location we compared hydroseeding, no-till drill seeding, and broadcast seeding followed by cultipacking, across three soil types using the same locally adapted native seed mix. At the other site we compared the effectiveness of two seeding mixes each seeded with both a no-till drill, and a Truax Trillion broadcast seeder, on two soil types. Results from these experiments show the ability to successfully restore pipeline rights of way with locally adapted native seed using several different planting methods and seed mixes. These results also demonstrate the ability of locally adapted native seed mixes to reduce the impacts of oil and gas activities across a variety of soils in the Eagle Ford Shale region of South Texas. We will present the results of these experiments as well as some key issues to address before reseeding pipeline right of ways.

STATE AND TRANSITION MODELS FOR RANGELANDS: WHERE ARE WE GOING FROM HERE?

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State and transition models (STMs) are used for communicating about ecosystem change in rangelands and other ecosystems, especially the implications for management. The fundamental premise that rangelands can exhibit multiple states is now widely accepted. The current application of STMs for management, however, has been limited by both the science and the ability of institutions to develop and use STMs. We summarize the major debates regarding STM concepts and applications and explore why STMs have been limited in their application for management. We conclude with a summary of

actions that could increase the utility of STMs for collaborative adaptive management in the face of global change.

TEXAS TODAY: A SEA OF THE WRONG GRASSES.

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Exotic grasses impact tens of millions of acres of rangelands in Texas. Though widely planted and lauded for their ability to increase forage for livestock and prevent soil erosion on degraded rangelands in the last half century, today exotic grasses are increasingly viewed negatively by rangeland managers focused on wildlife. Exotic grasses are still used in many land management activities in Texas, including for reclamation, forage provision, and because effective native seeds for restoration and reclamation plantings are lacking in many regions. Ecological effects of exotic grasses vary, but many species have been documented to be problematic for biodiversity, particularly at lower trophic levels as evidenced by measured effects on grassland birds, arthropods and native forbs. Exotic grasses also alter ecosystem function, particularly fire ecology, nutrient cycling, and vegetation succession. Problematic exotic grasses in Texas include buffelgrass, Old World bluestems, and guineagrass throughout southern Texas; yellow bluestem in central Texas; bermudagrass and bahiagrass in eastern Texas; and Lehmann lovegrass in western Texas. Despite concerns about exotic grasses, and negative perceptions, little change has been made from policy standpoints at the state or federal level to reduce their use. Even the most problematic exotic grasses continue to be used extensively in federally-subsidized conservation programs, and exotic grass use in industry and on private lands remains common. A few agencies, such as the Texas Department of Transportation, have made notable changes to reduce their use of exotic grasses, as have many conservation-focused private landowners. Exotic grass problems may be exuberated in coming years because of widespread present use of these plants on oil and gas pipeline and electricity transmission line right of ways. Perhaps most concerning, the removal of established exotic grasses and restoration of native plant communities remains a daunting and expensive endeavor on most Texas rangelands.

ECONOMIC IMPACTS OF INCREASING SEASONAL PRECIPITATION VARIATION ON COW-CALF ENTERPRISES.

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Economic impacts of predicted increases in precipitation variability on cow-calf enterprises, through influences of precipitation on both forage and cattle productivity, are needed by land managers for risk management strategies. Here we utilize existing forage production and cattle performance data from the Northern Mixed-grass Prairie, coupled with spring precipitation and economic data, in a ranch-level mathematical programming model to estimate economic impacts for three scenarios across a 35-year planning period with 100 iterations of different price cycles including five levels of increasing spring precipitation variation (10, 20, 30, 40 and 50% increases) for three separate scenarios. Our first scenario

examines the impact of resulting forage production from spring precipitation variability; the second scenario examines the impact of precipitation variability on calf gains; and the final scenario examines these two factors combined. Annual expected profit variability increases largely due to the increase in herd number variability rather than variability in calf gains. Overall, higher annual expected profit variability results in greater risk of negative returns from cattle. An important implication from our results is that the wet years do not overcome the negative impacts of the dry years given relationships between precipitation, forage production, and calf gains utilized in our model. Results indicate greater profitability in maintaining lower herd numbers in preparation for drought rather than destocking during drought events and restocking during good years for cow-calf operations. The results also illustrate the need for producers to diversify their operation and or income sources if they are to cope with increased precipitation variability even if mean annual precipitation remains constant.

VEGETATION CHARACTERISTICS OF CRESTED WHEATGRASS STANDS VARY BY SEEDING YEAR PRECIPITATION, DISTURBANCE HISTORY, AND MANAGEMENT.

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Crested wheatgrass, an introduced bunchgrass, has been seeded on millions of acres of the sagebrush steppe. Stands of crested wheatgrass are often associated with native species displacement and low biological diversity; however plant community composition can be variable. We evaluated 121 crested wheatgrass seedings across the northern Great Basin to investigate correlations between vegetation composition and seeding year precipitation, disturbance history and management. We found that high precipitation following seeding of crested wheatgrass has long-term, negative effects on Wyoming big sagebrush cover and density. Crested wheatgrass stands that were grazed contained more native herbaceous vegetation and shrubs than ungrazed stands. Pre-seeding treatments/disturbances also appears to have long-term effects on plant community characteristics. Results of this study explain some of the differences in plant community composition among sites seeded with crested wheatgrass. These results also suggest management actions can be used to affect the cover and abundance of native vegetation in crested wheatgrass stands.

POPULATION ECOLOGY OF BIG SAGEBRUSH AND IMPLICATIONS FOR SAGEBRUSH MANAGEMENT.

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As good condition sagebrush steppe continues to be lost, it becomes increasingly important to improve our understanding of the biology and ecology of big sagebrush (*Artemisia tridentata*). One of the less well understood aspects of the biology of sagebrush is its population ecology. Stand age structure, or demography, is one of the most basic measures used to understand the stand condition of woody plants. It has been suggested that big sagebrush stands can become decadent due to old age of the individuals within the population and that management action would be required to rejuvenate that

stand. The potential for decadence due to old age can be revealed by examining the stand age structure. Few efforts to measure the stand age structure of big sagebrush have been reported. We selected 14 one-hectare plots in an area of primarily Wyoming big sagebrush (*A. t. wyominensis*) that appeared to represent a broad range of sagebrush size, density, cover, and condition. From each plot we collected stem cross sections from approximately 70 total individuals of big sagebrush; including approximately 50 live and 20 dead sagebrush stems. Growth rings on each cross section were counted to determine age of live shrubs and age at death for dead shrubs. The overall average age of the 636 cross sections of live sagebrush was 14.9 years. Mean age per plot ranged from 7.3 to 22.6 years. Maximum ages of live sagebrush ranged from 22 to 86 years. Only 7% of the individuals sampled were two years old or less. Mean age at death ranged from 25.9 to 49.4 years. All plots had uneven stand age distributions indicating that all plots were experiencing ongoing, periodic recruitment events. The stand age distributions observed do not suggest big sagebrush stands might become decadent due to old age.

NORTHERN BOBWHITE RESPONSE TO THERMAL HETEROGENEITY: IMPLICATIONS FOR GROUND-DWELLING BIRDS IN RANGELANDS.

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Although temperature is acknowledged as a driver of galliform population dynamics and individual behavior, the mechanisms behind these relationships are unclear. For example, the influence of thermal landscape patterns on northern bobwhite (*Colinus virginianus*) site selection during critical life history periods is poorly understood. We assessed black bulb temperatures (Tbb) and vegetation parameters at 87 bobwhite nests and paired microsites, and 38 brood locations at the Packsaddle Wildlife Management Area in western Oklahoma during 2013 and 2014. To characterize the thermal landscape, we also sampled Tbb and vegetation at 205 points that were distributed by vegetation type using a stratified random sampling approach. We found that the thermal landscape exhibited substantial heterogeneity, demonstrated by differences in Tbb up to 40ËšC during peak diurnal heating. Nest and brood sites selected by bobwhites moderated Tbb by more than 5ËšC and 10ËšC compared to the surrounding landscape, respectively. Additionally, on days experiencing ambient temperatures ≥ 39ËšC, successful nests were on average 6ËšC cooler than unsuccessful nests. During peak diurnal heating, broods behaviorally modified their thermal exposure by curtailing movement and seeking shelter in patches of tall densely canopied woody cover. However, concomitant to climate change scenarios, our modeled Tbb measurements suggest that thermal environments will become more extreme and will occur for longer portions of the day, potentially increasing thermal constraints on bobwhite behavior and site selection. These findings suggest that future conservation efforts should include the maintenance of thermal complexity at scales relevant to ground-dwelling birds. Furthermore, they underscore that rangeland landscapes should be viewed as dynamic thermal mosaics which influence site selection during critical reproductive stages and highlight the ecological relevance of landscapes as moderators of thermal extremes.

EFFECTS OF CLIMATE ON SCALED QUAIL NEST SUCCESS AND BROOD SURVIVAL.

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Across the southwestern U.S., scaled quail (*Callipepla squamata*) have been experiencing a contraction of their distribution range-wide. Habitat loss has been highlighted as one of the main causes of this range contraction, however areas in western Texas managed specifically for scaled quail are still seeing declines in populations, indicating that these declines may be independent of habitat-related factors. With climate models forecasting a shift in monsoonal seasons from June and July to August and September, scaled quail populations may be negatively impacted by changes in temperature, humidity, and precipitation during their critical reproductive period. In order to determine the potential impacts of these predicted changes on scaled quail populations, we are studying the effects of temperature, humidity, and precipitation on nest success rates in southwestern New Mexico during the 2014 and 2015 breeding seasons. Results from our first field season indicate scaled quail nesting begins in May before summer monsoon rains begin and increases after the start of the monsoon season in July. Nest success was high pre and post monsoon, however brood success was significantly higher after the start of the monsoon season than the pre monsoon period. Hygrochron temperature and humidity sensors placed in and immediately outside of nests indicate that hens are particularly good at buffering fluctuations in ambient temperature but poor at buffering nests against ambient humidity. Nest humidity closely tracked both dry and wet conditions (20-80%) throughout the incubation period. Overall, scaled quail had high nest success across a wide gradient of climate conditions, but brood success appears to be linked to seasonal monsoon precipitation patterns.

THE SOCIETY FOR RANGE MANAGEMENT AND SOIL HEALTH: THE MEANING OF HEALTH AND THE SRM MISSION.

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The Society For Range Management recognizes the basic role that healthy soils play in producing the goods and services managed for on rangelands throughout the world. Healthy soils are required to produce healthy plants and healthy animals on rangelands. We recognize that mismanagement or inappropriate monitoring and response can result in loss of soil that often requires evolutionary time to replace. It is a primary goal and significant part of the SRM mission to understand soil and soil process better, such that managers can be informed as to how to monitor and manage the soil resources, by managing the integral plant and animal communities associated with rangelands. By their nature, rangelands are found in areas typically not suited to intensive agriculture and where abiotic conditions can be relatively harsh. These harsh conditions require managers to adapt conventional agronomic views and practices to fit the conditions of the specific rangeland considered. As we move into a time where climate change becomes more apparent, adaptive methods of monitoring and management of soil and soil processes will be critical to maintaining healthy rangeland ecosystems and the goods and services associated with them. SRM champions the efforts made by managers and scientists working together to form the Rangeland Health initiatives and development of Ecological Site Descriptions.

These are tools that have at their very core, considerations of soil health and link the abiotic and biotic systems. We look forward to future studies that can help to improve these tools and help mangers of rangeland resources achieve sustainable production in healthy, functioning ecosystems.

OVER-ESTIMATION OF AVAILABLE HABITAT FOR BISON IN THE GARDINER BASIN, MT.

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In an effort to address bison movement outside Yellowstone National Park (YNP) the Interagency Bison Management Program (IBMP) is addressing bison population size and its distribution. One of the alternatives is the creation of special management areas outside YNP where bison would be able to range freely across the landscape. The Gardiner Basin is a proposed management area. However, US Forest Service biologists are concerned about the impact bison may have on rangeland and watershed condition, especially if grazing becomes more common during summer months. We investigated which areas within the Gardiner Basin are most likely to be grazed by an expanding herd. Initial efforts to identify characteristics of bison summer habitat area based on information contained in the "Predicted Bison Habitat in Gardiner Basin Map" (PHGB), part of the IBMP plan, indicated potential errors in the estimation of the amount of available habitat, so we developed a similar GIS-based model to refine area estimates within both YNP and the Gardiner Basin. Our model added landform slope to the other habitat characteristics correlated to bison use of summer habitat within YNP. The outcome was revealing 98% of the summer habitat inside YNP area fall within the class of gently to moderately steep slopes (<35%), while the PHGB shows only 67.8% within the same class (<35%); 2) our model predicts only 7,950.4 acres what is much smaller than the 25,533 acres in the PHGB. Based on these outcomes it became clear that available bison habitat in the Gardiner Basin is not sufficient to sustain large herds for extended periods, therefore long term summer use by bison must be closely monitored to avoid overgrazing, changes to the grassland communities, loss of dominant grass species and corresponding declines in watershed condition.

CONCEPTUAL ADVANCES THAT HAVE TRANSFORMED THE RANGELAND PROFESSION DURING THE PAST 25 YEARS.

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This presentation will highlight the major conceptual advances that have occurred in rangeland science and management during the past 25 years. These rapid advances appear to have been a consequence of the juxtaposition of multiple, interrelated events that occurred within a relatively short period to markedly transform the rangeland profession. These critical events occurred both internal and external to the rangeland profession and they comprised both scientific and socio-political developments. The most influential ecological, scientific and socio-political events contributing to transformation of the rangeland profession in the past 25 years were rapid woody plant expansion that solidified dissatisfaction with the traditional range model, the introduction of resilience that provided a

conceptual framework for development of an alternative rangeland assessment procedure, and the National Research Council's report on Rangeland Health that delivered the political momentum necessary to implement this change. This series of interrelated events created conditions that challenged the traditional concepts and provided insights necessary for development of alternative concepts at a time when the scientific capacity of the profession was rapidly increasing. A new era of rangeland science has emerged based upon the implications of these recent conceptual advances to management recommendations and policy decisions within the context of coupled human-ecological systems that are confronting 21st century challenges.

EFFECT OF DIFFERENT LEVELS OF BIG SAGEBRUSH COVER ON GROUNDWATER IN A FOOTHILLS RANGELAND WATERSHED.

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Over the past two decades considerable information on the effect of woody plants on groundwater recharge patterns has emerged. The dominant woody species has ranged from large shrubs like mesquite (*Acacia* ssp) and juniper (*Juniperus* ssp) to trees like Douglas fir (*Pseudotsuga menziesii*) and Ponderosa pine (*Pinus ponderosa*). In contrast little attention has focused on smaller species like the sagebrushes (*Artemisia* ssp.) and rabbitbrushes (*Ericameria* and *Chrysothamnus* ssp.). Efforts to control woody density to limit the impact of climate change on stream flow patterns may be less successful if these smaller species intercept groundwater before it reaches feeder streams. Previous prescribed fire research in Montana indicated that much of the change in shallow groundwater occurred with 2m of the surface following fire. Hydrologic studies in watersheds following sagebrush control indicated shifts in soil water at a similar depth. A controlled watershed study to evaluate the effect of sagebrush cover on shallow groundwater levels was begun in southwest Montana in 2012. Ten monitoring wells were established in each of five sub watersheds forming the headwaters of a third order tributary of the Madison River. Twenty percent of the sagebrush was removed each year in four of the units. By 2015 37 – 58% of the cover had been reduced in treatment watersheds. The number of wells with standing groundwater increased from 1 in the pre-treatment year to 5 by 2015. Groundwater persisted in 3 of the wells through September each year. No such patterns were observed in the untreated drainage. Elevation as well as annual snow cover are controlling factors in groundwater response. All the wells with water occur above elevations of 1800m. Drainages below this elevation level have not responded to sagebrush thinning. Snow accumulation and persistence may play a larger role in groundwater patterns than sagebrush cover.

RESTORATION OF NATIVE PLANTS TO HISTORIC PAD SITES AND IMPACTS OF LIVESTOCK ON RESTORATION PLANTINGS.

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Oil and gas activities, particularly road and drilling pad site construction, impact large acreages of native rangeland across the country. These activities destroy, fragment, and introduce invasive species into native rangelands. Many landowners attempt to restore historic wells pad sites to native vegetation, often with varying results. To test the ability of a locally adapted native seed mix made up of grasses, forbs, and legumes we attempted to restore 4 former oil and gas well pad sites to their historic grassland state. Adding to the complexity of the restoration process, these pads were located within large grazing units making it unfeasible to exclude grazing. We evaluated the ability of the native seed mix to establish and persist, and the effects of grazing by cattle the on the restored sites for 3 years after planting. By 7 months post seeding we were able to establish ≥0.5 seeded native plants per 0.25 m2. Cattle grazing had little effect on the density of seeded species that established. Cattle grazing did have minor effects on species composition; however these effects are not likely to create any long term effects on species composition. These results are promising to landowners attempting to perform native grassland restoration on sites impacted by oil and gas activities in South Texas.

GREATER PRAIRIE-CHICKEN THERMAL ENVIRONMENTS IN HETEROGENOUS TALLGRASS PRAIRIE.

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The impacts of climate driven change on ecosystem processes and biodiversity are pervasive and still not fully understood. Biodiversity loss, range shifts, and phenological mismatches are all issues associated with a changing climate that are having significant impacts on individuals and ecosystems alike. Investigating and identifying effective management strategies that can conserve vulnerable species should be the focus of current and future climate change research. We investigated thermal properties of habitat for an imperiled grouse (Greater Prairie-Chicken; *Tympanuchus cupido*) in tallgrass prairie characterized by heterogeneous fire and grazing (the fire-grazing interaction). We examined operative temperature at varying scales relevant to grouse and used historic and forecasted climate data to estimate thermal stress during nesting activities. We found that heterogeneous grasslands have high thermal variability with operative temperature ranging as much as 23° C across the landscape. Grouse exhibited strong selection for cooler thermal environments as nest sites were as much as 8° C cooler than the surrounding landscape, and fine-scale differences in thermal environments was nearly 4° C cooler than sites within 2 m of nests. Additionally, forecasted climate scenarios indicate grouse will experience 2-4 times the number of hours above thermal stress thresholds, emphasizing the need for informed conservation management. Overall, these data provide evidence that variation in grassland structure resulting from the fire-grazing interaction may be important in moderating thermal environments and highlights the complex and interactive effects of restored ecological processes on ecosystems

MONITORING PROTOCOLS: OPTIONS, APPROACHES, IMPLEMENTATION, BENEFITS.

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Monitoring and adaptive management are fundamental concepts to rangeland management across land management agencies and embodied as best management practices for private landowners. Historically, rangeland monitoring was limited to determining impacts or maximizing the potential of specific land uses – typically grazing. Over the past several decades, though, the uses of and disturbances to rangelands have increased dramatically against a backdrop of global climate change that adds uncertainty to predictions of future rangeland conditions. While the multi-dimensional monitoring needs for rangeland management must be reconciled with the harsh realities of the costs to collect the requisite data, conceptual advances in rangeland ecology and management over the past 25 years, driven by developments in ecological theory, and changes in natural resource policies and societal values have facilitated new approaches to monitoring that can support rangeland management's diverse information needs. Additionally, advances in sensor technologies and remote-sensing techniques have broadened the suite of rangeland attributes that can be monitored and the temporal and spatial scales at which they can be monitored. We review some of the conceptual and technological advancements over the past 25 years and provide examples of how they have influenced rangeland monitoring. We then discuss implications of these developments for rangeland management and highlight what we see as challenges and opportunities for implementing effective rangeland monitoring. We conclude with a vision for how monitoring can contribute to rangeland information needs in the future.

EVALUATION OF UTAH TREFOIL COLLECTIONS FOR RANGELAND RESTORATION/REVEGETATION IN THE SOUTHERN GREAT BASIN.

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Wildfires, weed invasion, and various other land disturbances are common in rangeland ecosystems of the Intermountain Region in the western U.S. Revegetation/restoration may be required on many of these rangelands to improve degraded conditions, speed recovery, and minimize soil erosion. Legumes native to the Great Basin are of particular interest in rangeland revegetation/restoration because they have the potential to biologically fix nitrogen, provide high protein forage for livestock and wildlife, and enhance native pollinator habitat. However, few Great Basin legumes are commercially available as seed. Utah trefoil (*Lotus utahensis* Ottley) is a legume species that is native to the southern Great Basin and occurs in southern Utah, southern Nevada, and Arizona. Seed was collected from 19 sites throughout its distribution, plants were germinated and grown in a greenhouse, and transplants were established in common gardens at three sites in northern Utah. Plant development, morphological and physiological characteristics, forage quality, tannin content, and genetic diversity are being evaluated for each of the collections. Results from these evaluations will be discussed in relation to the development of a strategy for the eventual release of pre-variety germplasms of Utah trefoil.

SAGE-GROUSE AS AN UMBRELLA SPECIES IN NORTHWESTERN COLORADO.

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Reduction in sagebrush rangelands has resulted in sagebrush avifauna population declines across western North America, triggering a need to better understand relationships between environmental characteristics and avifauna resource needs. Sage-grouse may act as an umbrella species to manage for multiple species that rely entirely or partially on sagebrush rangelands, but the efficacy of such approaches is often assumed. Therefore, we surveyed greater sage-grouse [GRSG] and sagebrush songbird habitat use in northwestern Colorado in order to determine the amount of habitat overlap between sage-grouse and three sagebrush-obligate songbirds (Brewer's sparrow [BRSP], sage thrasher [SATH], and sagebrush sparrow [SASP]), and one shrub-obligate species (green-tailed towhee [GTTO]. During May and June 2013-15, we conducted standard point count breeding surveys for songbirds and GRSG pellet count surveys within a 10-m radius plot at each songbird point. We then modeled songbird abundance or GRSG relative abundance using remotely-sensed data to create count-based regression models and determine correlation in predicted counts for GRSG and the songbird species. Greater sage-grouse, BRSP, SATH, and GTTO counts increased with an increase in sagebrush cover and species responded to a different scale of sagebrush cover, as well as different non-sagebrush predictors. There was a high, positive correlation between GRSG and BRSP and SATH predicted counts and a weak positive correlation between GRSG and GTTO counts. Sagebrush sparrow counts increased with moderate amounts of sagebrush cover, resulting in a negative correlation between predicted GRSG and SASP counts. In our study area, GRSG may be an effective umbrella species for some sagebrush-obligate species, but SASP appear to use areas with less shrub cover. Given the potential federal listing of GRSG, land managers and biologists should have an understanding of how managing for GRSG habitat could affect other sagebrush avifauna species. Managers and landowners could also incorporate avifauna habitat use into state-and-transition models to more effectively manage for multiple ecosystem services.

BIOMASS PRODUCTION AND VEGETATION RESPONSE TO TEBUTHIURON TREATMENTS IN MOUNTAIN BIG SAGEBRUSH COMMUNITIES IN UTAH.

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Historic grazing practices coupled with decreased fire frequency in mountain big sagebrush (*Artemisia tridentata var. vaseyana*) communities has resulted in artificially high shrub canopy cover causing limited herbaceous understory. Several types of treatments are used by rangeland management to reduce sagebrush canopy and have been applied to sagebrush systems for decades. Generally, the objective of these treatments are to produce more herbaceous biomass for livestock and/or improve habitat for wildlife such as sage grouse (a species of conservation concern). However, scientific evaluations of herbaceous biomass and vegetation responses to chemical treatment, such as tebuthiuron, are limited in mountain sagebrush communities. We evaluated herbaceous biomass production and vegetation response in mountain big sagebrush communities using five pastures that

were treated with tebuthiuron within different years (2006-2012). To evaluate herbaceous biomass production and vegetation response since time of treatment, we will analyze the data collected using an effect size analysis. This research will help managers better understand how tebuthiuron impacts herbaceous biomass production and mountain big sagebrush ecosystems. This information is critical for managing livestock and wildlife in mountain sagebrush ecosystems.

AN 80-YEAR STUDY OF THE INFLUENCE OF WEATHER ON PLANT PRODUCTIVITY AT ONEFOUR, AB.

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The productivity of a dry mixed prairie site at Onefour, AB Canada was sampled annually from 1930 through 2014, with only 5 years missing. Simple weather records were collected concurrently. In addition to updating previous modeling of weather effects on productivity, changes over time were examined to test for climate change. Over the 80 years, forage productivity increased with time (linear R2 = 0.335; quadratic R2 = 0.439). To refine the effect of time more clearly, we applied a linear plateau model to productivity which revealed a break point in 1973, after which there was a linear increase in productivity. Post 1973, the climate became more humid with a linear increase in April-July precipitation (r = 0.30) and a linear decrease in May-July pan evaporation (r = -0.58). There was little change in maximum daily temperature (r = -0.04). Stepwise multiple regression relating weather factors to productivity were separately for the two 40 year periods. In the first 40 years precipitation was the main explanatory variable followed by maximum temperature (multiple R2=0.64). This was similar to previous modeling efforts. In the second 40 years pan evaporation was the main explanatory variable followed by precipitation (multiple R2=0.57). As these two variables changed with time, climate change was partly driving yearly variations in productivity during the second 40 years.

MECHANISMS OF THERMAL VARIATION IN SHRUB COMMUNITIES.

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Future projected climatic trends indicate overall increases in temperature and environmental stochasticity throughout much of the North American rangelands. Understanding how organisms might respond to changing climatic conditions has become increasingly important as species' requirements (i.e., niche conservatism) may restrict or change behavioral patterns. For instance, thermal stress from extreme heat has been shown to restrict movement patterns and space use of terrestrial vertebrates, in which organisms select certain vegetation cover as a thermal refugium during times of thermal stress. Though thermal conditions (operative temperature) may be modified by vegetation structure such as woody cover, an understanding of how the vegetation may physically influence the mechanisms ultimately determining operative temperatures is still lacking. We sought to determine how two shrub species, sand sagebrush (*Artemisia filifolia*) and aromatic sumac (*Rhus aromatic*), alter the physical mechanisms that may result in lower operative temperatures during heat events (>30°C) within a semi-

arid rangeland in Beaver county, Oklahoma. Starting in 2015, we monitored operative temperatures within a treatment (underneath the shrub canopy) and compared these temperatures to a control (1 m outside the shrub canopy). While recording temperatures, we measured physical conditions underneath and within the shrubs to relate back to operative temperatures. These conditions included: light reflectance and absorption, photosynthetic active radiation (PAR), light reflectance of soil underneath the shrub, wind permeability/turbulence, sonic temperature, soil temperature, and moisture along a transect within the shrub's crown. Traditional structure measurement techniques (i.e, crown spread, crown depth, and shrub height) were used to relate shrub structure to temperatures. Finally, a field LiDAR was used to obtain point clouds of shrubs, which allows us to measure shrub structure in 3-dimensional space. Pilot data was obtained in August of 2015 and subsequent data will continue to be collected during the summer of 2016.

PROVISION AND USE OF ECOSYSTEM SERVICES.

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Ecosystem services are benefits that society receives from landscapes, and can include food, fiber, and wood, the regulation of climate, the pollination of crops, and the provisioning of intellectual inspiration and recreational environments. They usually involve several ecological functions and processes such as primary production and nutrient cycling, and they are intimately inter-related with biological diversity. Ecosystem services are generally classified in four different types: provisioning, supporting, regulating, and cultural, and landscapes have provided this array of goods and services to humans for millennia. Certainly, the emphasis in recent decades has shifted from managing for a sustained supply of ecosystem services to reconciling supplies with competing demands. Land management is increasingly focused on reconciling supply of and demand for ecosystem services among different stakeholders. What has changed is the ecological, social and economic complexities of the competing demands for ecosystem goods and services. This reconciliation is primarily a function of 3 drivers: landscape capacities, socio-economic conditions, and time. Each driver has key gradients that dictate either supply of or demand for ecosystem services, or both. How these various gradients of these drivers interact is a major determinant of ecosystem services supplied from any landscape. Increasingly, land management either influences or is influenced by the interactions of time, landscape ecology, and human demands. Applying principles of land management is only part of the issue in supplying goods and services from rangelands. Understanding these drivers, their gradients and their interactions is critical as we transform and continue the provisioning of ecosystem services from rangelands as both supplies and demands change over time.

TARGETED GRAZING AND HERBICIDE FOR DALMATIAN TOADFLAX AND GEYER LARKSPUR MANAGEMENT.

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Rangeland weeds are costly pests, reducing forage, adversely affecting livestock, or increasing producers' expenses. Some, like the invasive Dalmatian toadflax (*Linaria dalmatica* [L.] Mill.), are considered noxious throughout the west. In contrast, the native Geyer larkspur (*Delphinium geyeri* Greene) is limited in distribution but associated with high spring cattle mortality. Research that evaluates grazing as a management tool for these two species is limited and sometimes conflicting. Our objectives were 1) to determine effects of sheep grazing on Dalmatian toadflax, Geyer larkspur, and associated vegetation, and 2) to compare grazing to herbicide treatments. We allowed ewes to graze experimental units at a constant stocking rate, but varied grazing timing and frequency. We also applied two herbicide treatments (metsulfuron and chlorsulfuron+aminocyclopyrachlor) in spring 2014. We measured cover, biomass, and weed density. All grazing treatments initially reduced larkspur density and limited its regrowth in the two months following grazing (P<0.0015). However, only herbicide had residual effects on larkspur density in 2015 (P=0.0001). More than 80% of toadflax stems were impacted in all 2014 grazing treatments and events, and 45-70% of stems in 2015 treatments (P<0.0001). In midsummer 2015, chlorsulfuron+aminocyclopyrachlor provided the best toadflax control, and the treatment grazed twice annually appeared to limit toadflax spread better than other grazing treatments (P<0.065). Although perennial grasses were visually impacted by all grazing treatments, we observed biomass production similar to the check in all but one treatment in midsummer 2015 (P=0.0476). Two years may be insufficient time to see impacts of repeated heavy grazing in this study system.

ANIMAL ACTIVITY INFLUENCES BY GRAZING STRATEGY.

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Grazing strategy is reported to affect animal movement and energy expenditure. Activity (steps taken) of yearling steers was studied using three different grazing strategies on Sandhills subirrigated meadow at the University of Nebraska Barta Brothers Ranch 11 km northwest of Rose, Nebraska. The grazing strategies were a 4-pasture rotation with a single occupation, a 120-pasture rotation with a single occupation (ultrahigh stocking density), and continuous grazing; there were two replications of each strategy. The research was conducted during a 60-day grazing period from mid-June to mid-August in 2013, 2014 and 2015. Each pasture in the 4-pasture rotation was 0.42 ha and grazed by 10 steers for 15 days and each pasture in the 120-pasture rotation was 0.14 ha and grazed by 36 steers for 0.5 day. The continuously grazed pastures were each 0.75 ha and were grazed by 4 steers for 60 days. In each year, two to four steers in each treatment replication were randomly selected and fitted with IceCube pedometers for the entire 60-day grazing period. We hypothesized that animal activity would increase as pasture size increased and as the length of grazing time in a pasture increased, thus continuously grazed pastures will have the greatest activity while ultrahigh density grazing will have the least number of steps per day. However, steers in ultrahigh stocking density pastures in 2013 took 40% more steps than steers in other treatment pastures through most of the grazing season. In 2014, steers in ultrahigh stocking density pastures took a greater number of steps in mid-July (39% greater) and late-July (30% greater) only. Data from 2015 steers remain to be analysed but the greater number of steps taken by

steers in the ultrahigh stocking density pastures may be a result of behavior changes associated with stocking density.

THE RECOVERY PROCESS OF WORTHEN&ACUTE;S SPARROW ON A GRASSLAND MANAGED AREA IN NORTHERN MEXICO.

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The Worthen sparrow is an endemic and endangered species restricted to the Mexican plateau. It occurs at ecotone zone between the microphillum scrubland and prairie dog colonies. Most of its ecological information has been generated at marginal habitats such as overgrazed shrubland-grasslands. Rancho Los Angeles owned by Universidad Autonoma Agraria Antonio Narro is a unique private and managed grassland area into the prairie dog colony complex in Coahuila state. In 2010, a new management grazing scheme was initiated in order to promote habitat heterogeneity for grassland bird conservation. In 2013, 2014, and 2015 we found 43, 74 and 70 nests, respectively, with a total of 187 nests occupying five different cattle pastures. Nests substrate, nest site characterization, reproduction success, causes of mortality on nestlings and nest material construction were evaluated. The most preferred nest substrate was Mariola (*Parthenium incanum*) and Tarbush (*Flourensia cernua*), both representing at least the 90% of substrate species. Brush canopy cover around the nest decreases as distance increases, and brush density increases as distances increases. Using remote cameras, 6 mortality causes were recorded. Road runner (*Geococcyx californianus*) was the main predator with 4 events, following of snakes (*Pituophis deppei*) with 2 events, white footed mice (*Peromyscus leucophus*) and ants with 2 events, respectively, Bobcat (*Lynx rufus*) and hypothermia with one event, respectively. Regarding nest construction material, ring muhly (*Muhlenbergia torreyi*) occupies at least 93% of nest material. Another 10 grass and herb species were found with no more than 1%, including horse and cow hair.

TIPPING POINTS FOR WEATHER AND POST-FIRE WIND EROSION ON RANGELANDS: PATTERNS, PROCESSES, AND PREDICTION.

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Weather is a major driver of fire and ecosystem recovery or degradation following fire, in shrub steppe and other semiarid rangelands. In particular, weather is the principle agent driving erosive losses of soil following fire, which can have dramatic effects on ecosystem recovery and poses a number of risks to humans and rehabilitation efforts. Predicting where and when wind erosion is likely would be a key step towards improving post-fire rehabilitation of rangelands. Wind erosion results from the wind generated by weather, but also from weather effects on protective vegetation or litter cover, soil wetting/drying cycles, and physical impaction of soil surface surfaces. Published and preliminary evidence reveal ways that weather-related forces have threshold effects on wind erosion, particularly on erosivity of the landscape (vegetation growth) and particularly erodibility of soil (threshold windspeeds, which are affected by moisture). Prospects exist for combining weather forecasts along with weather and wind

erosion probabilities based on historic tendencies of ecological site types to help predict where and when erosion risks are likely.

LIVESTOCK PRODUCTION SYSTEMS.

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Rangelands, 50% of the earth's land surface, produce a renewable resource of cellulose in biomass that is uniquely converted by ruminant livestock into animal protein for human consumption. Globally, increasing livestock numbers are driven by increasing incomes in emerging economies of Africa and Asia. Although livestock production systems have benefited from many technological (e.g., artificial insemination, growth hormones) and conceptual (e.g., ecosystem engineering, targeted grazing, distribution of livestock grazing across landscapes) advances already, sustainable intensification is needed to meet global animal protein production demand by 2050 while also reducing the environmental footprint of livestock. Increasing "more intensive" type production systems that incorporate grains and improved feed efficiency will reduce time from birth to harvest, use fewer resources and have lower greenhouse gas emissions per unit of animal protein than "less intensive" or "extensive" systems. Intensification of rangeland systems can occur by interseeding legumes and/or use of bioenergy protein by-products for increased dietary protein, developing forage "hot-spots" on the landscape, adaptive grazing management in response to a changing climate, improving fertility to increase birth rates, and reducing livestock losses due to disease and pest pressure. Rapidly emerging DNA and RNA genetic tools, combined with the completion of genomic sequencing for livestock, provide capacity for advancement of genomic selection programs. In summary, livestock production systems must intensify their activities by introducing knowledge and technology that not only assures sustainable production, but also through transparent efforts that increase societal confidence in the quality of animal protein for consumers.

ADAPTING TO CLIMATIC VARIABILITY FOR LIVESTOCK OPERATIONS: FLEXIBLE STOCKING STRATEGIES.

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For livestock managers, incorporating flexible stocking strategies with intrinsically high inter- and intra-annual variability in forage production is difficult due to enterprise-level and economic constraints. Adapting to climatic variability for livestock operations requires that adjustments in stocking strategies are made when temporally appropriate (both within and across years). Proactive and flexible stocking strategies should vary stocking rate with forage availability, as determined by using seasonal weather predictions to adjust stocking rate, and then carried out at the enterprise-level by incorporating yearlings into the livestock operation. However, a recent survey of Wyoming ranchers revealed than

only 16% of livestock managers are using weather predictions to adjust stocking rate, even though this strategy has high potential to increase economic returns as well as provide flexibility for drought management. A new study in Northern Mixed-grass Prairie, at the USDA-ARS High Plains Grasslands Research Station is addressing the use of flexible stocking strategies for adapting to climatic variability. Developed relationships between spring (April + May + June) precipitation and forage production as used to determine annual stocking rates that vary across years though use of observed precipitation amounts and predicted (from Climate Prediction Center) seasonal forecasts. Stocking rates are estimated in early spring (April 1) using the predicted seasonal forecasts and then adjusted May 1 and June 1 using observed precipitation amounts plus updated seasonal forecasts. This flexible stocking strategy will be compared to set-stocking strategies across each year of light, moderate and heavy grazing to determine efficacy of livestock gain responses and economic returns.

SEASON OF PRESCRIBED BURNING ON KLEBERG BLUESTEM (DICHANTHIUM ANNULATUM) IN SOUTH TEXAS.

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Kleberg bluestem (*Dichanthium annulatum*), a warm-season perennial bunchgrass is native to both the Asian and African continents, was introduced to South Texas during the 1930s. Its subsequent invasion of the region has greatly impacted native plant communities and the wildlife that inhabit them. We conducted a season of burning study to evaluate the use of prescribed burning as a control method for Kleberg bluestem. We investigated effects of both summer and winter burning on individual, as well as community-level metrics to better understand the initial impact of the fire treatments. Early results from the first year of burning indicated that summer burning can produce higher mortality rates in Kleberg bluestem than both winter burning and control treatments. However, both burning treatments increased seedling recruitment over control treatments, although we have not had sufficient time to determine whether recruits will become established successfully. Burning in either summer or winter did not affect individual plant production. These early results indicate neither summer nor winter burning is effective for short-term control of Kleberg bluestem as a single treatment, although summer burning is a better choice than winter burning. Treatments will be repeated in future years to investigate the long-term effects of repeat treatments.

READING THE RANGE: VGS FACILITATES COLLABORATIVE RANGE MONITORING.

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Reading the Range (RTR) is a collaborative rangeland monitoring program established primarily on the Tonto National Forest (TNF) in central AZ. The RTR program was started in 2001 due to a lack of data to better describe conditions on federal grazing allotments for the National Environmental Policy Act (NEPA). Partners have included the Natural Resources Conservation Service, the University of AZ

Cooperative Extension, TNF range staff and grazing permittees, and the interested public and other government employees. The Extension model was the demonstration ranch. Acreage of allotments on the TNF enrolled in RTR has increased from 40,469 ha in 2001 to 606,624 ha in 2014. As more participants enrolled in RTR, we implemented using the Vegetation GIS Data System (VGS) midway through the 2008 monitoring season. Users of the software included all the partners listed above, from ages 7.5 to 70 years. Some of the older users had never used any type of computer when introduced to the software, yet the software is user friendly and relatively error proof. The VGS software also reduces fatigue and increases the enjoyment in data collection. In 2015, a statistics program paid for by Public Lands Council Endowment Trust grant funds was incorporated into VGS to better inform data reporting. Users of the software, both ranchers and agency employees, are able to generate reports to assist in range management and NEPA documents. Recently, several ranchers have loaded the VGS software onto purchased field tablets and received additional training (along with agency employees) in using the enhanced software for data collection and in generating reports. It is estimated that using the software has reduced office data entry time by 50 hrs/allotment and by an additional 10 to 20 hrs/allotment for data reporting functions.

WEATHER TOOLS FOR RANGELAND RESTORATION AND REHABILITATION IN THE WESTERN USA USING CLIMATEENGINE.ORG.

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The advent of high-resolution historical climate datasets paired with seasonal climate forecasts provide the potential to improve monitoring and planning for climate sensitive resources. However, the sheer size and complexity of these datasets limits their ability to be used by a wide range of stakeholders. We present a web-based application that overcomes these barriers called Climate Engine. Climate Engine utilizes 1) Google Earth Engine's parallel cloud computing platform to process large amounts of data and to enable users to interactively visualize different climate and remote sensing metrics at multiple time scales and in near real time and 2) University of Idaho web services to disseminate downscaled seasonal climate forecasts for the next 7 months from the North American Multi-model Ensemble project. The web services we developed allow the download of CSV files of point location data and the visualization of the forecast data with a) time series comparisons to historical averages and percentiles for point locations and b) spatial maps of the forecast projections for each month from the different models in the ensemble. By improving access to this data and to real-time visualizations, we aim to improve decision-making regarding restoration/rehabilitation activities.

VEGETATION RESPONSE TO MOWING IN WYOMING BIG SAGEBRUSH PLANT COMMUNITIES IN THE GREAT BASIN.

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Thousands of acres of Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*) habitat have been mowed throughout Nevada and the surrounding Great Basin to create fuelbreaks for wildfire control, enhance resilience and resistance to invasive exotic plant species, increase perennial herbaceous understory, and improve wildlife habitat. To improve understanding of how these plant communities respond to mowing and whether treatment goals are being met, an observational study of 67 paired mowed and unmowed locations was conducted between 2010 and 2015 across the geographic extent of Wyoming big sagebrush in Nevada. Each study location was randomly located in a unique soil map unit within a unique mow treatment. Mow treatments were of different ages, and a different subset of the 67 locations was visited in 2010, 2011, 2012, and 2014. Foliar cover and sagebrush canopy volume data were collected in these years. In 2015, all the study locations were visited, and foliar cover, perennial herbaceous density, and soil profile data were collected. The data were analyzed to answer several questions. Does mowing Wyoming big sagebrush plant communities result in an increase in herbaceous perennial cover or density? Does the resulting shift in plant community composition improve resilience or resistance to invasive exotic plant species? How do these plant communities change relative to the age of the mow treatment? Are there different plant community responses based on soil, site, or unmowed plant community attributes? Are mow treatments effective as fuelbreaks, and if so, for how long? Addressing these questions empowers land managers to improve and optimize their use of mowing as a management tool.

TRANSLOCATING WILD-CAUGHT TEXAS HORNED LIZARDS INTO FORMERLY OCCUPIED HABITAT ON THE MUSE WMA.

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The Texas horned lizard (THL. *Phrynosoma cornutum*) has been in decline throughout much of Texas. Declines have primarily been attributed to habitat loss, introduction of red imported fire ants (*Solenopsis invicta*), environmental contaminants, and other factors that merit further study. Due to an overwhelming interest in reintroducing THL, researchers translocated 15 lizards from private property in Irion County to the Muse Wildlife Management Area (MWMA) in northeastern Brown County to evaluate the feasibility and success of reintroduction efforts. The lizards were released via soft release methods into a portion of the MWMA where habitat improvements had been made and where soils, vegetation, and density of red-harvester ants appeared appropriate to support THL. Each lizard was fitted with a 1.5 g backpack-style VHF radiotelemetry transmitter and was tracked daily from 12 June 2014–28 October 2014, at which time all remaining lizards were hibernating. Location data were collected to evaluate habitat use, home range size, dispersal distance, and causes of mortality. Eight lizards were tracked ≥ 30 days and 6 lizards survived until hibernation. Data analyses are still in progress; however, minimum convex polygons indicate home ranges varied from 63–392,266 m2 and dispersal distance ranged from 40–761 m. Researchers observed the majority of locations within 5 m of woody brush; however, habitat use analyses have not been conducted. Researchers observed mating behavior occurring in the research enclosure prior to release; 2 nests were later established. One nest containing 19 eggs was unsuccessful; however, the other nest hatched 21 eggs. Three hatchlings were observed during tracking operations on 16 September 2014. During 2015, researchers released 43

additional THL and emphasis will be placed on collecting habitat use and survivability information. Such data will help evaluate the feasibility of restoring THL populations back to areas they once existed.

THERMAL CONSTRAINTS ON REPRODUCTIVE PROCESSES FOR TWO SYMPATRIC GROUND-NESTING GALLIFORMS IN THE SOUTHERN GREAT PLAINS.

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Galliform populations in the Southern Great Plains are extremely susceptible to high heat, solar radiation, and drought at both population and individual levels. Nevertheless, our understanding of how thermally heterogeneous environments dictate the outcome of critical life history periods for ground-nesting birds is limited. This knowledge gap hinders our ability to understand thermal constraints on incubation as well as our capacity to predict the future impact of climate change on these species. Our objective was to investigate the way two sympatric species existing on opposite edges of their respective continental distribution behaviorally adjust to their surroundings and regulate incubation temperature. We assessed 22 scaled quail and 37 bobwhite nests and paired microsites at Beaver River Wildlife Management Area in the Oklahoma Panhandle during the 2015 nesting season. Incubation (Ti) and microsite (Tm) temperatures were recorded at 2 minute intervals for each nesting attempt. We observed that nest success was 62% for bobwhite and 29% for scaled quail respectively. Moreover, we found that maximum temperatures experienced at successful nests were up to 16°C (Ti=50.5°C) cooler than maximum microsite temperatures (Tm=66.8°C) whereas unsuccessful nests experienced greater thermal extremes (Ti=62.3°C, Tm=65.7°C). Additionally, incubation temperatures were on average > 5°C cooler than paired microsites indicating the fine scale variation in proximal thermal environments was substantial. Among species, we found that scaled quail Ti was up to 10°C hotter than bobwhite Ti throughout the season. Preliminary data indicates that quail are substantially moderating their thermal environment when constrained to thermal extremes. Research is ongoing and additional data will be used in projection models with climate change scenarios to help predict how critical life history periods will be affected in the future for these species.

THE EFFECTS OF PATCH-BURNING ON WILDLAND FUELS MANAGEMENT.

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Post-settlement alterations (through heavy grazing and fire suppression) to historical fire regimes in the southern Great Plains have contributed to a recent increases in wildfire activity in the region, resulting in unprecedented housing losses, increasing suppression costs, and increased risk to human life. The upward trend in wildfires necessitates development and implementation of fuels management practices, and prescribed fire will likely become the primary technique. However, grazing deferment, often implemented following fire on public lands, allows for rapid recovery of biomass. Rapid recovery

limits the utility of prescribed fire as a fuels reduction treatment unless large areas are burned annually. This approach can reduce landscape heterogeneity and confound other management objectives associated with biodiversity. When fire and grazing are applied to the landscape in a patchwork manner, an interaction occurs, increasing heterogeneity and supporting greater biodiversity. Our study investigates the effects of the fire-grazing interaction on fire behavior (flame length, rate of spread), and its ability to enhance suppression capabilities. Four southern Great Plains vegetation types are represented by sites across Texas and Oklahoma. Three sites practice patch-burning, while the fourth uses prescribed fire alone (no grazing). At each site, we measured fuel characteristics in patches with different times since fire, and used those characteristics to create custom fuel models to simulate fire behavior. Sites subjected to fire alone recovered in biomass faster than grazed sites. Simulated fire behavior in these sites also reached high intensity earlier than patch-burned sites. Our results suggest that patch-burning can extend the utility of fire as a fuels treatment, making suppression of active wildfires more successful.

EFFECTS OF TANGLEHEAD EXPANSION ON BOBWHITE HABITAT IN SOUTH TEXAS.

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Usable space has been reduced by the increase of non-native, invasive grasses over a considerable portion of South Texas. These grasses generally form high density monocultures and often are associated with increased herbaceous vegetation height, losses of forb and native grass diversity, and reduction of bare ground cover. Tanglehead (*Heteropogon contortus*), a native grass, recently has acted as a non-native, invasive, increasing rapidly and forming high-density monocultures in the western Sand Sheet area of South Texas. Consequently, tanglehead may be negatively influencing the structure and floristics of northern bobwhite (*Colinus virginianus*) habitat on native rangelands in South Texas. The objective of our research was to determine the relationships between tanglehead and habitat characteristics considered important for bobwhite habitat. We surveyed 20,103 hectares on 4 ranches during spring 2015, measuring vegetation on 488 transects. We measured tanglehead canopy cover, forb and grass species richness, bare ground, herbaceous vegetation height, and shrub cover at each transect. We also determined the soil series at each transect. We modeled the relationships between tanglehead and vegetation factors using quantile regression, at the 10th, 50th, and 90th quantiles, while soil relationships were determined graphically. We found significant negative relationships between tanglehead cover and forb and grass species richness, bare ground, and shrub cover at all quantiles. Tanglehead cover showed a significant positive relationship with vegetation height for all quantiles. Tanglehead cover was highest on reddish-brown, loamy fine sandy soils of the Comitas and Delmita series. Our results demonstrate the negative effects of increased tanglehead cover on native rangeland habitats. Increases in vegetation height as well as reductions in vegetative diversity and bare ground can have negative impacts on the wildlife community, notably grassland birds such as bobwhites. Further expansion by tanglehead has the potential to significantly reduce both range and wildlife habitat quality in South Texas.

PATTERNS OF CHEATGRASS (*BROMUS TECTORUM*) INVASION IN THE NORTHERN GREAT PLAINS.

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Cheatgrass (*Bromus tectorum*), is an invasive, exotic annual grass found throughout North America. Cheatgrass has been extensively studied in the Great Basin region of North America where the majority of precipitation comes in winter and early spring, and the vegetation consists primarily of cool-season species. However, relatively little research has been done in the Northern Great Plains region where most precipitation comes in spring and summer, supporting a mixture of cool- and warm-season plant species. As climate and vegetation differ between the Northern Great Plains and the Great Basin, the ecological impacts of cheatgrass in the Northern Great Plains are unknown. In order to better understand cheatgrass ecology in this region, we created a study to assess cheatgrass invasion and abundance in the distinct climate of the Northern Great Plains. Fifteen study plots were established at each of two ranches in Montana, both of which are owned and operated by the Montana Agricultural Experiment Station: Thackeray Ranch, southeast of Havre, MT, and Red Bluff Ranch, east of Norris, MT. Within these plots we examined relationships among cheatgrass abundance, biotic and abiotic site characteristics (e.g. species diversity, aspect, ecological site description), and disturbance indicators (e.g. livestock fecal counts) in 2014 and 2015. An initial generalized linear mixed-effects regression model was reduced to simpler models by comparing the Aikake's Information Criterion (AIC) for each fitted model, and selecting for lower AIC to best predict cheatgrass abundance. Based on these models, site characteristics such as aspect and ecological site within the context of known disturbance may be important predictors that land managers in the Northern Great Plains could use to estimate the risk of cheatgrass invasion or dominance on the landscapes they manage.

THE IMPORTANCE OF THERMAL REFUGIA AT THE SOUTHERN EXTENT OF WHITE-TAILED PTARMIGAN RANGE.

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Extending south to a latitude of slightly below 36 degrees North, the Sangre de Cristo Mountains of northern New Mexico is the extreme southern extent of White-tailed Ptarmigan (*Lagopus leucura*) distribution. Little is known about the historical distribution within the state or what factors may limit their distribution or abundance. Since 2007, we have conducted surveys of alpine habitat to identify occupied range in New Mexico, and to determine factors important for the persistence of the species within the state. The Sangre de Cristo Mountains in New Mexico contain approximately 70 square kilometers of alpine habitat above 12,000 feet (3658 meters); however, 98% of all ptarmigan sign (feathers, feces, or sightings) were found above 12,300 feet (3750 meters), even though only 35% of the alpine is above that elevation. Based on our surveys, we estimate that approximately 15 to 20 square kilometers are occupied by ptarmigan, at least seasonally. However, some seemingly suitable peaks and ridges at or above 12,500 feet (3810 meters), especially along the western edge of the range, that are either known or assumed to have been occupied historically are currently unoccupied. These high elevation areas along the western edge are typically warmer and drier than areas of similar elevation

further east. At this southern latitude, we theorize that elevation (above 3750 meters), the presence of willow thickets, and the presence of thermal refugia (boulder fields and rifts) are all necessary for ptarmigan occupancy. We compared summer temperatures on the surface and within likely thermal refugia locations between unoccupied and occupied mountains, and suggest that elevation, the presence or absence of refugia, and location all contribute to suitability of a particular peak or ridge. We will summarize the present status of White-tailed Ptarmigan in New Mexico and results of our thermal research, and will discuss possible limiting factors affecting the sustainability of White-tailed Ptarmigan in New Mexico, especially the possible threats related to climate change and the importance of thermal refugia.

GRASSLAND BIRD COMMUNITY RESPONSE TO SERICEA LESPEDEZA CONTROL USING FIRE AND GRAZING.

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Sericea lespedeza (*Lespedeza cuneata*) is an invasive forb that reduces native grass and forb abundance in tall-grass prairie by up to 92%. Owing to its high fecundity, phenology, and high tannin content, traditional management techniques (i.e., herbicide use, prescribed spring fire, and cattle grazing) are of limited utility in controlling the species. Conversely, we have found the use of 1) mid- and late -summer fire and 2) grazing by a combination of steer and sheep to be useful methods for sericea lespedeza control in the Kansas Flint Hills. To evaluate the effects of these methods on tall-grass prairie wildlife communities, we assessed the breeding grassland bird response. We conducted fixed-radius point counts and monitored grassland bird nests to measure grassland bird community composition and estimate reproductive output. Grasshopper sparrows (*Ammodramus savannarum*) were more abundant in mid-summer and late summer fire treatment units than in spring fire units as well as in units grazed by steer and sheep compared to units grazed by only steer. Grassland bird species diversity, species richness, density, and reproductive output did not differ between treatments and controls. Our results indicate that summer prescribed fire and additional grazing by sheep will not negatively impact the grassland nesting bird community in the tall-grass prairie and grasshopper sparrow populations may benefit from such treatments.

WOODY PLANT ENCROACHMENT AND EFFECTS ON SOIL HEALTH.

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Sustainability of range plant communities is in-part determined by the proper function and condition of the soil. In rangeland plant communities that have been encroached by woodland species (e.g., Pinyon pine and Juniper) soil erosion rates can be significantly increased. Understory vegetation is often reduced in the interspaces between trees due to competition. This provides a feedback loop in that bare soil is increased resulting in increased raindrop splash erosion and concentration of runoff in the

interspaces as hydraulic roughness is lower due to lack of herbaceous plants and litter in the interspace. This combined affect results in significant removal of soil and nutrients offsite through accelerated soil erosion processes. Once initiated these concentrated flow paths (rills) remain intact and deepen with each succeeding runoff event if the encroaching tress are not removed and replace with appropriate shrub and herbaceous vegetation. Sustainability and soil health is compromised in this situation as once a significant amount of soil is removed the capacity of the site to provide goods and services is diminished in perpetuity. The end result is a development of an alternative ecological state with diminished capacity for goods and services. Rangeland communities are further influenced by episodic disturbances such as drought and fire. The most-developed quantitative indicators of conservation effects currently on rangelands are 1) modeled soil erosion, and 2) the density and types of invasive plant species. Current technology to estimate soil erosion on upland rangelands with the Rangeland Hydrology and Erosion Model and potential thresholds of soil erosion that will have negative impacts on soil health as a result of woody plant encroachment, invasive species, and fire will be presented and discussed. Benefits of conservation to reduce or prevent soil loss and reduction in soil health will be discussed using examples from Pinyon-Juniper woodlands and Oak Savannahs.

BUFFELGRASS AND MULE DEER IN THE STATE OF SONORA, MEXICO: THE GOOD, THE BAD AND THE UGLY.

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Large Matorral areas in Sonora Mexico have been inter-seeded with buffelgrass for beef production. Ranchers prefer the species because it is easy to establish, requires low rainfall; has high productivity, good forage value and sustains overgrazing. The species is causing a monoculture problem on areas where complete brush clearing occurred for grass establishment. It is considered an invader; it is apparently displacing native species and is either limiting or reducing diversity on rangelands. Many scientists and ranchers do not completely agree with these evidences. With good plant establishment practices and proper management strategies, most natives not only can be kept on place, but can be spread while increasing buffelgrass forage productivity. Management of mule deer populations is getting very important for ranchers because of the extra income they get from the range with hunting. One mule deer trophy can produce up to 10,000 dollars profit, while a cow can yield from 470 to 705 dollars per year. This means a rancher can achieve the same amount of money with one mule deer trophy as compared with 14 to 21 productive cows. Studies have shown that buffelgrass is not an important component on mule deer diets; however, ranchers keep seeing high mule deer populations feeding in buffelgrass pastures. Deer possibly is consuming more grass than we think. We believe young leaves and shoots may be playing an important part on deer diets selection but young fresh leaf tissue may be disappearing during the digestion process. This may be the reason why buffelgrass does not appear on fecal samples. Ranchers wonder, if buffelgrass is not an important specie for mule deer then why big, mule deer trophies have been consistently harvested on buffelgrass improved rangelands. Research studies are required to understand the reason why deer populations seem to like these habitats.

COMMUNITY ASSOCIATIONS OF GRASSLAND BIRDS ON GRAZED MIXED-GRASS PRAIRIE OCCUPIED BY BLACK-TAILED PRAIRIE DOGS.

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North American grassland birds are one of the fastest and most consistently declining groups of species in the world. Declines are due to habitat conversion, removal of native grazers, brood parasitism, fire suppression, energy development, and other factors. The objective of this study was to identify associations and factors that shape the community of grassland birds in areas occupied by black-tailed prairie dogs (*Cynomys ludoviciana*) and grazed by livestock. The project was conducted on the Standing Rock Sioux Reservation in north central South Dakota. The study site is mixed-grass prairie and consisted of four pastures stratified by the proportion of prairie dog occurrence within a pasture. Pastures were stocked with Angus steers to achieve 50% degree of disappearance of vegetation. Bird and vegetation surveys were conducted from 2012-2014 along fixed-width belt transects located both on and off prairie dog colonies. Non-metric multi-dimensional scaling (NMS) was used in the analysis of community data and completed using PC-ORD 6. Distinctive communities of birds and vegetation occurred on and off prairie dog towns. Basal bare ground was the most important habitat variable associated with differing bird communities. Horned larks (*Eremophila alpestris*), were associated with plant communities with greater basal bare ground. Plant communities associated with increasing maximum live vegetation and visual obstruction had higher observations of grasshopper sparrows (*Ammodramus savannarum*) and were typical of off-town locations. Bird species such as western meadowlark (*Sturnella neglecta*) and upland sandpipers (*Bartramia longicauda*) utilized both on- and off-prairie dog town locations. Our findings demonstrate the importance of maintaining spatial heterogeneity for maintaining diverse and robust bird and plant communities at the landscape scale. Our findings coincide with earlier studies which have found that distinct bird and plant communities exists on and off towns and confirm that these patterns continue to exist in a system used for livestock production.

THE VALUE OF OFF-STREAM WATER DEVELOPMENTS IN PROTECTING RIPARIAN AREAS, IN NORTHEASTERN OREGON.

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While off-stream water developments have long been considered a valuable tool for managing rangeland livestock distribution, actually quantifying the efficacy of these developments has been difficult. Continuous monitoring of the timing and intensity of livestock use near water developments has been challenging. Refinements in GPS tracking technologies, however, have provided a means to

address this knowledge gap. We conducted a 5-year study (2008-2012) at three study sites in northeastern Oregon to contrast relative cattle use near water infrastructure vs. stream riparian areas. Ten randomly-selected cows from different herds grazing each site, were fitted with GPS collars that recorded position, date, and time at 5-minute intervals throughout the grazing season. About 3.75 million cow positions were collected. Timing and duration of cattle occupancy in 60-m buffers along perennial streams and 60-m buffers around water developments were determined monthly and annually for each site. Cattle use varied substantially by site, month, and year. In some months, cattle exclusively used water infrastructure, and in others cattle almost exclusively used streams and riparian areas. Our results suggest off-stream water development can be highly effective for cattle distribution management. However, careful consideration of placement and development type are required to improve the likelihood that cattle will find and use these water sources thus decreasing their dependence on permanent streams and consequent impacts on aquatic and riparian habitats.

ECOLOGICAL SITE DESCRIPTION TRAINING AGENDAS.

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Increased demand for ESDs both internally and externally, as well as NRCS priorities for accelerated ESD development, highlight the need for a consistent, well-organized training plan and curriculum which bridges the gap between emerging science, technical standards, and development and use of ESDs. NRCS must determine the right combination of instructional formats to balance course requirements, the needs of learners, and the restrictions of time and money in order to develop the most effective and efficient curriculum. In 2011, a White Paper was developed by a group of NRCS technical specialist recommending the establishment of an Ecological Site Training Committee. The White Paper included a brief training plan. Subsequently, a National Ecological Site Training Team (NESTT) was established in May, 2013. The original charge to the Team was to 1)identify the target audiences for training, 2)identify training topics 3) evaluate existing training materials 4)identify methodology for training 5)identify job series, grade level appropriate training 6)identify sources of training and related costs 7)develop assessments for training 8) identify partnerships in training 9)develop a strategic plan and training structure and 10)develop an ESD marketing plan. The Team adopted an expanded structure consisting of an Executive Committee, Curriculum Managers and Lesson Plan Developers. Johanna Pate and Craig Busskohl, NESTT co-chairs will discuss the status of NRCS ESI/ESD training opportunities, format and availability. They will discuss the roles of the Executive Committee, Curriculum Managers and Lesson Plan Developers and report on the tasks completed.

CAN MULE DEER AND CATTLE COEXIST IN THE CHIHUAHUAN DESERT? EXAMPLE AT MAPIMI, DURANGO, MEXICO.

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The study of species coexistence is an important issue in ecology that has been reviewed under different ecological and evolutionary approaches. Knowledge of habitat use of sympatric species is necessary to understand degrees of overlap and interactions intensity. Our main objective was to identify habitat use differences between mule deer (*Odocoileus hemionus*) and cattle (*Bos taurus*) in the Chihuahuan Desert of Mapimi Biosphere Reserve (MBM), Durango, Mexico. The use of different areas was evaluated through fecal group counts sampled every four months, from March 2010 through November 2011, in 328 fixed plot arranged on eight random transects. Habitat variables such as visibility, slope, altitude, and plant structure were obtained in this transects. For comparisons were applied two-way ANOVA, Kruskall-Wallis and and Mann-Whitney tests; correlations between habitat variables and fecal group counts, and a principal component analysis (PCA), were used to find which variabes influence habitat use. Significant differences were found for both, deer and cattle use between transects, seasons, and between the two species. Deer used higher, stepper areas, with high plant density and low plant richness, while cattle used flat, low areas, with low visibility. The first three components in the PCA explain 72.5% of variance. Deer and cattle differed in the areas they used, showing no competition for spatial resources under present circumstances at MBR.

SUBSURFACE SOIL HORIZONS DRIVE LANDSCAPE PATTERNS OF WOODY PATCHES IN A SUBTROPICAL SAVANNA.

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Grasslands and savannas around the world have experienced an increase in woody cover over the past century. However, the mechanisms responsible for the distribution of woody patches in savanna landscapes remain unclear. In the Rio Grande Plain of southern Texas, vegetation is characterized by a two-phase pattern consisting of discrete woody patches embedded within a grassland matrix. The soils on upland portions of this landscape are sandy loams with a laterally continuous subsurface argillic (Bt) horizon with non-argillic inclusions. Prior studies have suggested that large woody patches (> 100 m2) occur only on soils where the argillic horizon is absent. To test this hypothesis, we quantified landscape-scale spatial patterns of soil texture across soil depths by intensively sampling to a depth of 1.2 m in a 160 m × 100 m georeferenced plot subdivided into 10 m × 10 m grids. Kriged maps of soil clay content were developed for each soil depth increment throughout the upper 1.2 m of the profile, and the locations of non-argillic inclusions were mapped. Visually comparison of kriged maps to an aerial photograph of the study area showed that large woody patches were present only where the non-argillic inclusions were present. This clear visual relationship was further supported by strong negative correlations between soil clay content and the Normalized Difference Vegetation Index (NDVI) which mapped the locations of the woody patches. Subsurface non-argillic inclusions may favor the establishment and persistence of woody patches by enabling root penetration deeper into the profile, providing greater access to water, nutrients, and other soil resources that are less accessible on those portions of the landscape where the argillic horizon is present

CROSS-CONTEXT CONSISTENCY OF BEHAVIORAL TYPE DIFFERENCES IN RELATION TO PERFORMANCE OF ADULT RANGELAND-RAISED BRANGUS CATTLE.

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Behavioral syndromes, a term coined by behavioral ecologists, are suites of correlated behaviors that are consistently different among individuals across situations (e.g. feeding behavior on range pastures and in the feedlot), context (e.g. boldness in feeding, anti-predator, and mating behavior), and time. Because behavioral syndromes are consistent over time and context they can limit an animal's ability to adapt to varying environments and therefore can affect animal performance. The objectives of this study were to: 1) characterize behavioral syndromes in mature Brangus (*Bos indicus* influenced) cows in the Chihuahuan Desert; and 2) explore correlations among personality traits and their connections with cow performance. We found significant correlations between SCR (supplement consumption rate, a previously identified criterion to classify cows into behavioral types) and: dominance scores ($r = 0.96$; $P < 0.01$), shy proactive tendencies during shyness-boldness tests ($r = 0.61$; $P = 0.04$), area explored ($r = -0.57$; $P= 0.07$), feed neophobia, and both distance travelled ($r = -0.68$; $P = 0.02$) and habitat preference (-0.59; $P = 0.06$) on rangeland. We also found significant behavior - performance correlations including dominance rank vs. number of calves produced over a dam's life time ($r = 0.56$; $P = 0.06$), and calving Julian day (early vs. late calving) vs. area explored on rangeland ($r = -0.59$; $P = 0.07$), movement time and rate from water ($r = -0.58$; $P = 0.08$), and shade preference ($r = -0.79$; $P < 0.01$). Brangus cows exhibited suites of correlated behaviors that appeared to affect their individual performance. Our results highlight the importance of considering entire syndromes when selecting cows that exhibit rangeland-adapted behaviors.

EVALUATION OF SOIL TREATMENT TECHNIQUES ON REMEDIATED BRINE SPILL SITES IN WESTERN NORTH DAKOTA.

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Oil-produced water (i.e. brine) is a waste product of oil and gas extraction that can cause severe changes to soil chemistry and plant communities when discharged on the soil surface. The high concentrations of salts, dominated by sodium chloride, in brine overwhelm plants' ability to process large quantities of salt ions all at once, leading to ion toxicity and ultimately death. Brine also negatively impacts vegetation by lowering the osmotic potential in soil water, making it difficult for plant roots to extract water and essential nutrients from the soil matrix. Excess sodium ions weaken aggregate stability, impeding water infiltration and drainage. Brine spill remediation through topsoil excavation (*ex situ*) or chemical amendments (*in situ*) aim to remove or minimize the abiotic stressor to levels suitable for plant growth. The objective of this field study was to compare efficacy of these two soil treatment techniques by quantifying the remaining brine salts and plant establishment success on remediated sites. Study sites were located in the Little Missouri National Grasslands in western North Dakota. A paired-plot design was used to sample irregular brine spill sites, pairing each remediated brine spill site with a nearby

reference site of similar soil texture, type, and landscape position. Field data collection consisted of vegetation composition and biomass, and soil samples (0-15, 15-30, and 30-60 cm depths) at each site. Analysis included Relative Sørensen Dissimilarity Index to measure the degree of dissimilarity of each remediated brine spill to its nearby reference site. Data from this analysis will assess efficacy in brine spill remediation techniques to determine which method is more appropriate for the environmental conditions in western North Dakota.

WILD PIGS: IMPACTS ON NATIVE VEGETATION AND WILDLIFE.

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Given their recent range expansion and current distribution in the United States, wild pigs (*Sus scrofa*) are increasingly coming into conflict with humans, agricultural and natural resources, and other wildlife species. Wild pigs are characterized by invasive behavior across much of their global distribution, where they commonly reach unnatural population levels due to the absence of limiting factors, such as predators. In these and other scenarios, damage caused by wild pigs is often great, including negative impacts to rangeland ecosystems. Consequently, natural resource agencies and landowners engaged in wild pig damage management often have population eradication as their goal. However, in states where wild pig populations have become established, population reduction or control is often the goal. Unfortunately, many wild pig damage management programs are conducted in a piecemeal fashion, are not adequately funded, and lack clearly stated or realistic objectives. This presentation identifies damage caused by wild pigs to rangeland resources and describes techniques used to prevent and control their damage.

CATTLE GRAZING PREFERENCE OF PLANT COMMUNITIES WITHIN PRAIRIE DOG COLONIES.

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Prairie dog occupation of rangelands is often seen as a detriment to beef production because of altered plant communities and reduced quantity of forage. Within northern mixed grass prairie, plant communities on prairie dog colonies are often converted to low growing perennial grasses intermixed with patches dominated by annual forbs. Previous studies have indicated that prairie dog occupation can increase forage quality within town sites, and have evaluated impacts of prairie dog towns on cattle performance. Few studies have evaluated how cattle utilize various prairie dog town plant communities in terms of grazing preference. A study was conducted in 2012-2015 near McLaughlin, South Dakota in a mixed grass prairie ecosystem to assess cattle preference for plant communities on (PD) and off (NPD) prairie dog towns. Four 202 ha pastures were fenced with varying levels of prairie dog occupation (0%, 18%, 40%, and 75%). Each pasture was stocked with yearling steers grazed season-long from June to October. A subset of steers within each pasture were outfitted with Lotek 3300LR GPS collars equipped with motion sensors to help discriminate grazing versus non-grazing behaviors. During 2014 and 2015, satellite imagery was collected. Remote sensing techniques were used to establish training sites and

classify vegetation communities into annual forb dominated plant communities on town (PD-F), perennial grass dominated sites on town (PD-G), and grass dominated sites off town (NPD-G). GPS data correlated to grazing behavior was then used to assess cattle grazing preferences of PD and NPD plant communities throughout each grazing season. Understanding cattle grazing behavior can improve opportunities to manage prairie dog occupied pastures for livestock performance and to optimize rangeland health.

A NOVEL APPROACH TO MANAGING LARKSPUR TOXICITY.

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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. Incorporating data from a multi-year, ongoing study in northeastern Colorado, I will discuss the toxicity patterns of Geyer larkspur (*Delphinium geyeri*), a perennial, constitutively toxic species that declines in toxin concentration throughout the growing season. Evidence from this study points to hypotheses for future research and suggests that the most robust larkspur plants may also be the most toxic. If true, this suggests that current management, which is often aimed at avoidance during high-toxicity periods, may in fact be detrimental. While still in its early stages, this research holds potential to fundamentally alter our understanding and management of larkspur on western rangelands.

SOIL HEALTH IN GRASSLANDS: ARE THERE RELEVANT COMPARISONS WITH CROPLANDS?

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Interest has grown recently in the concept of soil health, particularly with the promotion of multi-species cover crops in croplands. The concept of soil health embodies earlier efforts on soil quality, but places additional emphasis on the soil biological component of a three-pronged approach to characterize soil physical, chemical, and biological attributes, as influenced by management. Soil organic matter quantity, quality, and depth distribution are key attributes that influence many of the physical, chemical, and biological properties and processes of interest. Therefore, a focus on soil organic matter characteristics is important to describe soil health. How soil organic carbon and nitrogen are influenced in quantity, quality, and depth distribution will be discussed in this presentation. Management approaches that influence these soil organic matter characteristics will be described and

reviewed for comparability with management approaches and their effects on soil organic matter in croplands.

HETEROGENEITY AS THE BASIS FOR RANGELAND MANAGEMENT.

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Range management, like most disciplines of natural resource management, has been characterized by human efforts to reduce variability and increase predictability in natural systems (referred to as command and control paradigm). Examples of traditional command and control in natural resource management include wildfire suppression, fences to control large ungulate movements, predator elimination programs, and watershed engineering for flood control and irrigation, including dams, terraces, and sub-surface tile drainage. Recently, a robust theoretical foundation has developed that now focuses on our understanding of the importance of variability in nature. This understanding is built upon the concept of heterogeneity, which originated from seminal calls to consider spatial and temporal scaling in ecological research. Understanding rangelands as dis-equilibrial ecosystems that are highly variable in space and time cannot be achieved without a focus on heterogeneity across multiple scales. We present example of the importance of heterogeneity of rangelands to 1) animal populations and production, 2) fire behavior and management, and 3) biodiversity and ecosystem function. Rangelands are complex, dynamic, and depend on the variability that humans often attempt to control to ensure long-term productivity and ecosystem health. We suggest an ecological perspective that targets variation in rangeland properties—including economic output in addition to ecosystem services—as an alternative to the myopic focus on maximizing agricultural output which may expose managers to greater risk. Globally, rangeland science indicates heterogeneity and diversity increase stability in ecosystem properties from fine to broad spatial scales and through time.

CHANGES IN VEGETATION DIVERSITY AND SOIL COMPACTION ON RECLAIMED MINED-LANDS OVER 40 YEARS OF RECLAMATION.

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Reclamation following anthropogenic disturbance often aims to restore stable soils that support productive and diverse native plant communities. Land reclamation regulations dictate the re-spread soil depths and grades as well as seed mixes, vegetation production standards and timelines. The soil re-spread process increases soil compaction, which may alter soil water, plant composition, rooting depths and soil organic matter. This may have a direct impact on vegetation establishment and species recruitment over time. Our objectives were to 1) evaluate the above and belowground vegetation patterns, 2) quantify changes in soil compaction, and 3) evaluate patterns of soil water across a 40-year reclamation gradient. We hypothesized that both alpha and beta diversity would increase and soil compaction would decrease with time since reclamation. Further, plant community patchiness and soil

water heterogeneity would increase over the 40-year reclamation gradient. Species composition and root depth, soil compaction, water content, and organic matter were recorded at 19 reclaimed and one native reference site in central North Dakota mixed-grass prairie. We determined the small scale dissimilarity of vegetation along with the average patch size and the highest mean dissimilarity between patches using dissimilograms based on the relative Sørensen dissimilarity index in PC-ORD 6.0. We used the gompertz equation and a non-linear regression using IBM- SPSS v: 21 to determine a 90% patch size within the landscape. Soil compaction, rooting depths and organic matter data was analyzed using a non-linear regression model. We rejected our hypothesis as alpha and beta diversity stayed steady over the 40 year reclamation gradient. This indicates that there is a lack of native species recruitment and establishment on the reclaimed mine sites. Relative plant community patch size and soil health on reclaimed lands over four decades will indicate the landscape-level success of the current ecosystem-based reclamation strategy.

RANGELANDS AS THERMAL LANDSCAPES: TEMPERATURE ACROSS SPATIAL AND TEMPORAL SCALES.

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Rangelands are increasingly appreciated for the importance for many ecosystem and landscape functions. One specific role of rangelands is moderating temperature extremes that may be important for ecological processes and biodiversity. Rangelands are dynamic in space and time and temperature extremes can be a critical pinch-point for maintaining critical populations and sustainably producing goods and services. I will present an overview of rangeland landscapes and the importance of temperature patterns in space and time. I will present examples of animal movement patterns that included ground nesting birds and large herbivores, as well as present examples of the magnitude of variability in thermal conditions on rangelands. Thermal patterns are important for understanding implications of rangeland management, especially in the face of projected climate change.

RESPONSE OF SAND SAGEBRUSH TO AN EARLY GROWING-SEASON WILDFIRE.

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Sand sagebrush (*Artemisia filifolia*) has been shown to actively resprout after prescribed fires; however, many land managers remain reluctant to use fire as a management tool for sand sagebrush shrublands. Cooper Wildlife Management Area in Woodward County, Oklahoma has been the site of multiple studies that used prescribed fire as a management tool for sand sagebrush. Using this past body of research, our objectives were to compare the effects of a stochastic wildfire to the effects of a prescribed fire on sand sagebrush. We measured sand sagebrush mortality, density, and physical structure 6 months after a 6 May 2014 wildfire. We also documented mortality within other species of shrubs on the management area. We used belt transects within the burned area to assess density, height, canopy area, and canopy volume of resprouting sand sagebrush. The point-center quarter

method was used to estimate mortality of shrubs other than sand sagebrush. We found that density of sand sagebrush after the wildfire did not differ from the density of unburned shrubs ($p = 0.863$) or shrubs burned with prescribed fire ($p \geq 0.245$) reported in prior studies. Though density was unaffected, shrub height, canopy area, and canopy volume differed significantly ($p < 0.05$) from unburned shrubs, as documented by previous studies. Of all non-sagebrush shrubs assessed, only Eastern red cedar (*Juniperus virginiana*) was severely negatively impacted with approximately 95% percent of cedar trees experiencing post-fire mortality. Sand plum (*Prunus angustifolia*) had low mortality (< 8%), and no mortality was observed for the 2 species of sumac (*Rhus* spp.). Wildfire did not negatively impact native shrubs, suggesting that sand sagebrush shrublands are highly tolerant of both prescribed and stochastic fires. Our results support the use of prescribed fires to manage sand sagebrush shrublands.

HOW DOES WINTER LIVESTOCK USE AFFECT MONGOLIAN RANGELANDS? LONG TERM INSTRUMENTAL AND FIELD OBSERVATION AT WINTER GRAZING PASTURES.

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There is a debate about the status and causes of rangeland changes in Mongolia. The primary cause is thought to be livestock population growth and decline of rainfall is a possible secondary cause. Field studies have focused on vegetation responses to grazing across a wide range of environmental gradients and the relative importance of abiotic and biotic factors on vegetation. Remote sensing studies have reported widespread degradation, but describe different extents and causes of rangeland change. Remote sensing studies can cover large areas and long time periods but require field validation. This study combines a broad –scale field data collection (143 winter pastures in 4 ecological zones) with a temporally sizeable remote sensing analysis to assess the long term effects of livestock on vegetation, forage quality and soils in Mongolia. At the field level, we measured the effects of livestock grazing around piospheres or grazing gradients created across winter pastures. In order to measure long-term grazing and climate effects, we quantified trends in livestock grazing intensity, biomass (MODIS NDVI) and climate variables to analyze change from 2000-2013 at 26 winter pastures in the mountain and forest steppe, steppe and desert steppe ecological zones. Our results show that grazing-induced changes were largest in the steppe (170 mm rainfall), moderate in the mountain and forest steppe (239 mm rainfall) and desert steppe (131 mm rainfall) and least in the eastern steppe (258 mm rainfall). Our study also showed that NDVI-derived biomass tracked grazing more closely in the mountain and forest steppe and steppe than in the desert steppe, as predicted by non-equilibrium rangeland dynamics theory.

EXTENT OF INDIRECT EFFECTS OF WELL PADS ON SOIL CHARACTERISTICS AND ARTHROPOD AND VEGETATION COMMUNITIES.

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The most obvious physical effect of an oil or natural gas drilling pad is the immediate area denuded of vegetation and subjected to vehicle traffic. However more subtle changes, such as alterations to microtopography and moisture regimes, emission of introduced gases, and deposition of sediment may have widespread and persistent effects as well as synergistic landscape-level effects. Grading and compaction of soil during construction may cause erosion, alter hydrology, and preclude reestablishment of natural vegetation communities. These changes in microclimate and soil characteristics may result in alterations in the abundance and distribution of the biotic community. We investigated the impact of well pads on soil surface temperature, thermogravimetric moisture content, vegetation cover and community composition, and arthropod abundance and diversity at four distances (-0.5 m, 1 m, 10 m, and 100 m) from well pads in Ellis County, Oklahoma. Our preliminary results show that vegetation height increased with distance from well pad, and all distances were significantly different. Litter depth was significantly greater in the 10 m and the 100 m distances than the -0.5 m and 1 m distance. Soil surface temperature was significantly greater in the -0.5 m distance than the 1 m, 10 m, and 100 m distances, while shrub cover followed the opposite pattern. Bare ground cover was lowest in the 100 m and 10 m distances, followed by the 1 m and then the -0.5 m distances. Forb cover was unique in that the 10 m distance had lower forb cover than the -0.5 m, the 1 m, and the 100 m distances. Warm season grass had greater cover in the 100 m distance than the closer three distances. Arthropod diversity and community response will also be presented. These results will be used to quantify the indirect footprint of a well pad.

WEATHER-CENTRIC STRATEGIES FOR RANGELAND RESTORATION PLANNING AND MANAGEMENT.

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Successful rangeland restoration requires significant cooperation from local weather over the long term, and at all stages in the life cycle of planted species. Restoration scenarios that focus on single-year intervention may yield short-term or partial success but not meet longer term objectives for establishment of diverse and resilient plant communities. Emerging technologies for characterization of local weather, seasonal forecasting, and life-stage specific modeling of seedbed microclimate may yield a more probabilistic/contingency approach to both planning and management of rangeland restoration projects. In this presentation we will present various tools for accessing local weather data and interpreting historical weather effects on the probability of initial seedling establishment, and some weather-centric adaptive management strategies for achieving longer-term rangeland restoration goals. These strategies are essential for taking advantage of emerging seasonal forecasting technologies, and to deal with potential impacts of future climate change.

TESTING PERFORMANCE OF CATTLE ON PASTURE WITH DIVERGENT MOLECULAR BREEDING VALUES FOR RESIDUAL FEED INTAKE.

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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 costs in beef operations. Measures of RFI however have only been evaluated under drylot conditions, where animals are on a standardized diet and foraging behaviour is effectively eliminated. This study was performed to explore the utility of RFI molecular breeding values by relating these to cattle performance while grazing under free-range conditions within heterogeneous pastures. The study was conducted at the University of Alberta Mattheis Research Ranch, just north of Brooks, Alberta in the Mixedgrass Prairie. A subset of commercial cows with known high and low molecular breeding values for RFI were evaluated for industry-relevant production metrics such as calf growth, cow rebreeding interval and cow weight gain and body condition recovery, during the summer of 2015. Calf birth weights were collected over the 1.5 month calving period. Cow weights and body condition scores (ultrasound ribeye fat and rump fat) were collected at pasture turnout in early June. Cow-calf pairs grazed from early June through until weaning in late October, at which time calf and cow weights, cow body condition, and dam pregnancy status were assessed. This presentation will present the results found and discuss any potential implications for the use of breeding values for RFI within extensively managed cow/calf operations.

RANGELANDS IN DEVELOPING NATIONS: CONCEPTUAL ADVANCES AND SOCIETAL IMPLICATIONS.

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Developing-country rangelands are vast and diverse. They are home to millions who are often poor, politically marginalized, and dependent on livestock for survival. Here we summarize work from six case study sites across sub-Saharan Africa, central Asia, and the Americas. We examine issues pertaining to population, natural resources, climate, land use, marketing, conflict, and livelihoods. As rangelands become more economically developed, livelihoods diversify and commercial livestock production expands. Pastoral livelihoods become more diversified, food security can improve, and wealth stratification among producers may widen. In some places significant investment in rural infrastructure and public service delivery has occurred. Telecommunications have improved everywhere because of mobile phones. Pressure from grazing, farming, mining, and other uses—combined with drought—can spur intense competition for resources. Internal and external factors have led pastoralists to become more sedentary, and herd mobility is reduced; such processes undermine traditional risk-management

tactics. Resource competition can foster social conflict. Remote rangelands offer safe havens for rebels, warlords, and criminals in some places; civil strife can undermine commerce and public safety. There has been tremendous growth in knowledge concerning developing-country rangelands, but this has not often translated into improved environmental stewardship or an enhanced well-being for rangeland dwellers. Research is shifting from ecologically-centered to more human-centered issues; academic approaches are often replaced by participatory community engagement. Building human or social capital in ways that are integrated with improved natural-resource stewardship offers the greatest returns on research investment. Future research and outreach priorities include improving pastoral governance, enhancing livelihood sustainability, and integrating this with better range and livestock management.

SOCIAL AND ECONOMIC ATTRIBUTES OF PUBLIC LANDS RANCHERS.

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Public land ranching is a significant component of many rural communities across the United States, contributing economically, socially, and ecologically to their well-being. Reliable information documenting characteristics of these ranchers is needed to help land managers and policy makers understand their economic and social diversity, how their operations affect the environment, and how ranchers contribute to their communities. We designed this study seeking answers to questions regarding the economics of ranching operations and how ranchers contribute revenue and sales to communities in their area. Questions also delved into the management practices implemented by ranchers to enhance wildlife habitat, fish production in streams, and riparian areas on both their public and private lands. A final goal of the study dealt with assessing how ranchers and their families interact socially within their communities. To gather this information, a nationwide survey was sent to a randomly selected group of public land ranchers. Surveys were mailed to 1,911 ranchers with a reminder postcard sent four weeks after the initial mailing and a second survey sent to those who had not responded within eight weeks. The survey had a 39% response rate. Nineteen different states across the nation were included in the returned surveys. Data show that family tradition and maintaining health and productivity of the land are the top reasons why ranchers continue to ranch. The biggest threats to the ranching operation were deemed to be endangered species and federal regulation and policy. Cluster analysis was used to determine different rancher types and those groups were compared with one another to determine how each group manages their lands and reacts to changes in policy.

UNDERSTANDING EXOTIC PLANT DOMINANCE IN BUNCHGRASS ECOSYSTEMS: ROLE OF HISTORICAL, BIOTIC AND ENVIRONMENTAL FACTORS.

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Understanding the underlying factors influencing exotic plant abundance and dominance is important to developing effective management and restoration strategies. We measured foliar cover of all vascular plants at 131 plots across The Nature Conservancy's Zumwalt Prairie Preserve in northeastern Oregon to evaluate the historical, biotic and environmental factors that best explained exotic plant abundance, distribution, and dominance. A total of 37 exotic species were encountered, the majority of which (62%) were forbs. However, the most abundant exotics were either annual grasses (*Bromus* spp., *Ventenata dubia*) or introduced perennial grasses (e.g. *Poa pratensis*, *Thinopyrum intermedium*). Exotic species abundance varied with past land use, environmental gradients and plant association. Seeded forage species such as *T. intermedium* and *P. pratensis* dominated abandoned cultivated fields. *Bromus* spp. were widely distributed across the landscape, but was associated primarily with *Festuca idahoensis*-*Pseudoroegneria spicata* associations. *Ventenata dubia* was the most abundant exotic species in the driest sites (*Danthonia unispicata* dominated sites). Results show that patterns of exotic abundance are the result of historical, environmental and biotic factors. Additionally, the relatively poorly studied and acknowledged weed, *V. dubia,* is a major invader of Pacific Northwest Bunchgrass communities. Moreover, results suggest that *V. dubia* is functionally different than annual *Bromus* spp., occupies different ecological niches, and is invading via different mechanisms. Thus, despite being an annual grass like *Bromus* spp., weed management approaches likely differ and species-specific approaches must be developed for this species. We then discuss implications of our findings for restoration and management of bunchgrass rangelands in the interior Pacific Northwest.

POST-FIRE DEFOLIATION: EFFECTS OF TIMING ON PRODUCTIVITY AND SPECIES COMPOSITION.

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In North American prairie it is acknowledged that defoliation events via bison grazing consistently followed fire. Given this evolutionary fire-grazing interaction, our objective was to determine whether post-fire timing of defoliation altered subsequent productivity and species composition. Following the April 2013 Pautre wildfire in the Grand River National Grasslands of South Dakota, we installed exclosures in three locations along the border of the fire. Grazing exclosures were paired across the fire line to create a "burned" and "unburned" exclosure at each of the three locations. Four plots were demarcated in each exclosure. Three plots were defoliated via mowing either 2, 4 or 6 months following the fire with the fourth maintained as a control. Productivity and species composition data were collected in November 2013, June 2014, August 2014 and July 2015. Fire increased productivity 56% during the 2013 growing season following the fire (P=0.0330). During the 2014 growing season, there was a trend for burned sites to maintain greater production (P=0.0832). June defoliation resulted in the greatest current-year productivity regardless of fire treatment, while all other treatments resulted in similar productivity (P=0.0299). Fire increased the presence of *Hesperostipa comata*, *Melilotus officinalis*, *Carex filifolia* (21 v 6%, 15 v 1%, 22 v 10%; P=0.0494, 0.0265 and 0.0479 respectively) during the first growing season. June defoliation reduced *Agropyron cristatum* (P=0.0228) and increased *M. officinalis* (P=0.0133) as compared to controls, but remained similar to other mowing treatments. *Koeleria macrantha* increased via August defoliation (P=0.0015) whereas *Nassela viridula* decreased from either June or August defoliation (P=0.0133). Initial results suggest that fire effects on productivity is limited to the first growing season following fire whereas defoliation effects manifest the second

growing season following fire. Additionally, both fire and timing of defoliation will disparately affect community composition.

ASSESSING THE IMPACT OF FUGITIVE ROAD DUST IN THE BAKKEN REGION OF NORTH DAKOTA.

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Energy production has increased over the last decade in the Bakken region of North Dakota with the use of new technology. This has resulted in an increase in traffic on unpaved roads in working rangeland landscapes. While sections of unpaved roads near rural residences and communities are treated with dust-reducing suppressants, little is done for range and farmlands. Our objective was to identify potential effects of fugitive road dust by determining: 1) the area of impact for dust deposition, 2) concentrations of dust particle sizes of concern for animal and human health, 3) patterns between environmental conditions, traffic counts and dust deposition, and 4) effects of dust on plant performance. Marble-pan passive sampler arrays were installed to collect fugitive dust in crop fields along transects perpendicular to roads. Particulate matter analyzers were used to collect concentrations of PM-10 and PM-2.5 at distances from roads. Wheat and corn fields were chosen for their regional prevalence and stand homogeneity. Deployed simultaneously, traffic counters and weather stations gathering temperature, relative humidity, wind direction, wind speed, and precipitation were installed at each site to contextualize dust deposition. We measured various plant physiological parameters including: photosynthetic activity, chlorophyll content, stomatal conductance, and leaf reflectance along transects perpendicular to the road. As energy production increases traffic in other working rangeland landscapes, our data connecting traffic and plant impacts from fugitive road dust are applicable to areas experiencing similar growth.

A SIMPLE, QUANTITATIVE APPROACH TO STATE AND TRANSITION MODELS AND ECOLOGICAL SITE CLASSIFICATION.

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The use of inventory data and previous scientific results to develop ecological site classifications and state-and-transition models (STMs) can be difficult. Here we draw on an example from a short-term project in the Calden region of central Argentina to illustrate a straightforward, logical approach to the use of data and prior results to develop a general STM. We used stratified random sampling (based on a general soil map) and opportunistic, targeted sampling of vegetation and soils at 47 points within the Caldenal region as a basis for classifying ecological sites and states. Cluster analysis on vegetation combined with nonparametric tests of cluster-environment relationships were used to evaluate patterns controlling the distribution of states in the landscape. Cluster identity was consistent with existing, informal concepts and state and transition concepts applied to clusters were based on existing studies

from the range management and ecological literature. Our data supported the utility of three ecological sites and five plant communities/states in the region. While the details of analysis necessarily vary among cases, this general approach can be useful in most settings. Two important insights emerge from our work in the Calden region and elsewhere. First, multivariate analysis using functional groups of plants, rather than complete species lists, can produce more interpretable classifications. Second, the occurrence of states tends to covary with environmental factors, such that sites and states cannot easily be disentangled. Thus, it may be useful to define state-and-transition models more broadly and to define the effect of environmental gradients on reference states and state transitions within general models.

VEGETATION RESPONSE TO WHITE-TAILED DEER FORAGING DOES NOT ALWAYS FOLLOW PREDICTIONS OF TRADITIONAL THEORY.

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Vegetation responses may be more strongly linked to environmental stochasticity than they are to herbivore density in semiarid rangelands. Although decoupling of vegetation and herbivores by environmental variability has been observed by several researchers, why and how it occurs is unclear. We conducted a decade-long experiment in southwest Texas, U.S.A., to determine the response of vegetation to white-tailed deer (*Odocoileus virginianus*) densities ranging from low (12 deer/km²) to high (50 deer/km²). Our results provide insight into some of the variables that may underlie the weak linkage between herbivores and vegetation in environments characterized by periodic resource pulses following precipitation events. We found that increasing deer density did not result in a decline in palatable plants or an increase in plants that are less palatable or are resistant to herbivory as predicted by traditional theory. White-tailed deer were primarily browsers during autumn and early winter, and shifted to a diet of primarily forbs during late winter to late spring when precipitation was above average. Deer consumed primarily mast during summer. Reduced browsing during spring and summer allowed woody plants to recover from defoliation during autumn and early winter, which ameliorated effects of deer density. Forbs were highly productive during wet years and virtually absent during dry years. Heat and lack of moisture during late spring caused palatable forbs to senesce before deer could reduce them, even at high deer density. By early summer deer shifted their diets to mast. This also helped to prevent deer from depleting palatable forbs, even at high deer densities. Generalist foraging behavior by deer, asynchronous plant phenology, and strong responses of vegetation to precipitation are among the variables that act to weaken the linkage between deer and vegetation in highly stochastic environments.

DOES SIZE MATTER? SCALING LEAF-LEVEL TRANSPIRATION OF CORNUS DRUMMONDII ISLANDS TO A WATERSHED.

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Woody plant encroachment has occurred in tallgrass prairie due to reduced fire frequency, climate change, and urbanization. One woody plant in particular, *Cornus drummondii*, a clonal shrub that forms monospecific stands has increased in abundance and cover to alter site ecohydrology. Because climate change predictions include hotter and drier conditions, competition for water among plant growth forms is likely to increase. During clonal expansion of *C. drummondii* individuals, we hypothesize that the larger islands will have increased water use because of higher levels of transpiration compared to the smaller islands, complicating landscape estimates of water flux. Our study site was the Konza Prairie Biological Station within a four-year burned watershed where 6 *C. drummondii* islands of varying sizes were chosen. Within each island, 5 ramets were chosen equidistant from the outer edge of the island to the center where leaf-level physiological data were measured bi-weekly during the summer of 2015. Ecosystem data from an adjacent Ameriflux tower was used for a scaling analysis between the leaf-level and watershed measurements. During the study no differences between predawn and midday leaf-water potentials were found between and among the varying island sizes. Net photosynthesis, stomatal conductance, day and nighttime transpiration measurements were generally higher in the small islands versus the medium and large islands. Interestingly, we also found that the outer most ramets of the islands had higher leaf-level measurements compared to the ramets within the island which had no differences. The small and large islands also had higher LAI values than the medium sized islands. These results facilitate creation of simpler models for scaling water fluxes from individual shrub islands to watersheds that are encroached with *C. drummondii*. Additionally, these results improve our ability to predict changes in water budgets between woody encroached grasslands versus unencroached grasslands.

SAGEBRUSH STEPPE SUCCESSION AFTER TREATMENTS TO CONTROL PINYON AND JUNIPER.

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Previous models of understory loss as pinyon and juniper tree cover increases indicated that perennial herbaceous loss precedes that of shrubs. On 10 western or Utah juniper and one or two needle pinyon pine sites across the Great Basin, we found that shrub cover was more sensitive to tree infilling than perennial herbaceous cover. Shrub cover was decreased to 50% of maximum when tree dominance (tree cover/ (tree + shrub + tall grass cover) exceeded 0.25, while perennial herbaceous cover decreased to 50% of maximum when tree dominance exceeded 0.5. Additional soil moisture from tree reduction, even 8 years after treatment, supported increases in both desirable and weedy understory cover. Six years after treatment, shrub cover averaged 4% on burned and 14% on tree cut plots compared to 7.8% on untreated plots. Tall grass cover averaged 16% on burn plots, 23% on tree-cut plots, and 12% on untreated plots. Cheatgrass cover was highest on burned plots at high initial tree dominance (9.6-14% cover at 0.65-1 initial tree dominance). Perennial herbaceous cover responded best to tree cutting even at high initial tree dominance (38 to 33.8% cover at 0 to 1 initial tree dominance). Perennial grass cover is a key component in these systems in avoiding the crossing of a biotic threshold by reducing weed dominance and avoiding crossing of an abiotic threshold by reducing interspace erosion. Continued

monitoring will be important in determining if perennial bunchgrasses will dominate and suppress cover of cheatgrass over time.

NORTHERN BOBWHITE HABITAT: THE NAMES CHANGE BUT THE PLANTS REMAIN THE SAME.

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The northern bobwhite (Colinus virginianus) has a huge geographic range that spans a north-south axis from Guatamela to southern New England and west to eastern Colorado. Across this range, a wide diversity of plants provide habitat resources that meet the annual life cycle needs of this species. Regardless of whether you are on a southeastern hunting plantation or a southwestern ranch, the habitat structure that supports bobwhites remains essentially the same. Little bluestem in the southwest is replaced by broomsedge in the southeast; both of these grasses provide preferred nesting cover. In the mid-west, sand plum provides woody cover and soft mast while American beautyberry provides the same in the southeast. Curiously, the inverse of this relationship also holds for the plants that destroy and degrade bobwhite habitat. Sod-forming fescues of the southeast are replaced by sod-forming bermudagrass in the pastures of central and south Texas; both of these grasses have devastated millions of acres of what used to be bobwhite habitat. Throughout the pine belt, too many pine trees preclude usable habitat space for bobwhites. It matters not if the pines are loblolly, shortleaf, or some other species of pine. Too many pines are too many pines. An appreciation of these regional habitat structure homologues can help managers understand how to provide usable habitat space for bobwhites regardless of the geographic location in which they work.

USING DIFFERENCED NORMALIZED BURN RATIO MAPS TO ASSESS WILDFIRE IMPACT IN WEST TEXAS AND AS AN OUTREACH TOOL FOR PRIVATE LANDOWNERS.

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Burn Severity Maps, or differenced Normalized Burn Ratio (dNBR) maps, categorize burned areas (soils and vegetation) into 4 levels: high, moderate, low, and unburned. These maps can be used to rapidly assess wildfire impacts across large, inaccessible landscapes, and also to support assessment of immediate impacts to soils, or short- to long-term impacts to vegetation. While their application as an outreach tool for the public has been largely unexplored, burn severity maps can be effective in helping landowners and land managers gain immediate understanding of the potential ecological impacts of wildfire and prioritize allocation of resources for burn recovery. Landsat satellite derived burn severity maps are commonly used in the management of public lands in the western U.S.; however, this is the first effort to validate and use dNBR maps in Texas as part of a cooperative effort with the Monitoring

Trends in Burn Severity (MTBS; http://mtbs.gov) project. We collaborated with the USDA Forest Service (USFS) Remote Sensing Applications Center (RSAC), the US Geological Survey (USGS) Earth Resources Observation and Science (EROS) Center, and the National Park Service (NPS) to produce and field-validate dNBR maps for the Davis Mountains, Texas, with the objective of providing a planning tool for recovery after the wildfires of 2011 and 2012. In comparison to other studies, our results demonstrated a relatively high level of agreement between dNBR maps and ground level measurements when we used combined plot values for Years 2011 and 2012 ($R^2 = 0.82$). However, the application of dNBR maps has not been sufficiently explored for all biophysical settings, including grassland communities. The usefulness of burn severity maps for rapid assessment has strong potential as an outreach tool for landowners and communities, and for long-term monitoring of soil and vegetation recovery and response to different levels of burn severity. When combined with other geospatial data such as digital elevation models, soil surveys, and land-use maps, dNBR could be a valuable tool for prioritizing post-fire natural resource restoration efforts. As a result of these implications, the USDA Natural Resources Conservation Service will be incorporating burn severity maps as an outreach tool to private landowners, and evaluating their use to monitor long-term recovery and planning.

MANAGERS' USE OF EXTERNAL INFORMATION SOURCES FOR RESTORATION DECISIONS.

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Rangeland managers in the Great Basin face many difficulties in restoring rangelands after species invasions and fire. Economic pressures restrict the amount of preventive restoration that is possible in a triage effort to restore lands already critically damaged by invasive species and fire. Societal pressures determine what restoration practices are accepted by the public and, to an extent, the areas restoration efforts target. Institutional pressures can enforce time restraints that limit the extent of restoration and follow up management. Ecological characteristics of the land can also challenge restoration efforts when those characteristics work against the desired condition restoration is working toward. The four above challenges are not always independent of each other and sometimes can form a complex web of factors that hinder restoration. These challenges are compounded by the unpredictability of weather. With accurate predictions of the weather six to nine months out, restoration efforts could align with weather conditions and have higher success levels. A team of scientists is trying to make this a reality by designing and marketing a new online rangeland management tool that uses short-term climate projections to inform restoration and post-fire rehabilitation decisions. However, in order for this tool to be successful, rangeland managers need to be an active part of its creation. Focus groups and interviews were conducted in which rangeland managers were asked a variety of questions that determined the factors influencing their management decisions. Rangeland managers would be interested in a tool that streamlined their decision making process by bundling data from multiple sources. Additionally, participants stated even a 10-20% increase in success rate would make the tool worth their time. The information from these focus groups will be integrated into the creation of this tool; thereby increasing the odds that rangeland managers will trust the tool with future restoration efforts.

NORTHERN BOBWHITE USE OF RESTORED NATIVE VEGETATION.

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Conversion of native grassland to non-native grasses poses a threat to grassland birds, including northern bobwhites (*Colinus virginianus*). Coastal bermudagrass (*Cynodon dactylon*) is a non-native grass that is planted widely for cattle grazing in the southeastern United States. The objectives of this study were to document and compare bobwhite abundance and survival on coastal bermudagrass pasture, a native shrubland community, and a former coastal bermudagrass pasture restored to native vegetation. In addition, we compared bobwhite habitat on these sites and 2 additional restored sites. We separated the bermudagrass sites into 2 sites for vegetation sampling. On these sites, we sampled vegetation using fifteen 25-m transects. We monitored relative abundance of bobwhites from trapping and whistle-counts. Bobwhite site use and survival was documented using radio-telemetry. During 2014, we trapped 105 individual bobwhites in the restored site, 27 in native shrubland, and 4 in the bermudagrass sites. These results coincided with our habitat results; the restored site had 6.26 times more grass clumps suitable for nesting than bermudagrass site 2 and nearly 13 times more than bermudagrass site 1. During 2015, we trapped 77 bobwhites in the restored site, 24 in native shrubland, and 34 in the bermudagrass sites. The habitat was drastically different in 2015, with the restored site providing a similar density of suitable nesting clumps as the bermudagrass site 2 and just over twice as many as the bermudagrass site 1. The cause of this difference was high spring precipitation and low levels of grazing on the bermudagrass sites in 2015. To our knowledge, this is the first study to quantify the effects of bermudagrass pasture on bobwhite abundance. This study reinforces the hypothesis that bermudagrass provides poor habitat for bobwhites and that bobwhite habitat can be successfully restored in pasture previously dominated by bermudagrass.

HERCULES AND THE HYDRA HYPOTHESIS: IS RANGELAND RESTORATION MORE EFFECTIVE WHEN COMBINED WITH FIRE?

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According to the Greek myth, Hercules was successful in slaying the nine-headed Lernaean Hydra where others failed because he used fire to quickly cauterize the stump of each serpentine head he chopped off before it could regrow into multiple new heads. This may prove to be a fitting analogy for land managers who have difficulty controlling woody encroachment in rangelands where persistent resprouting shrubs decrease biodiversity and degrade ecosystem services. Increasingly, attempts to utilize multiple management strategies are being employed to potentially maximize the efficacy of woody control treatments and decrease economic costs associated with methods requiring expensive machinery or synthetic herbicides. However, few systematic, quantitative assessments of the effectiveness of these various treatment combinations currently exist. Using data from several

experimental studies in woody encroached rangelands we assessed the factorial effectiveness of mechanical cutting, chemical herbicide applications, or ungulate grazing on resprouting woody plants coupled with and without prescribed fire treatments. The first study assessed the interactive effects of fire and cattle grazing on a problematic shrub found in degraded South African grasslands. A companion study in Texas coastal grasslands examined the effects of fire and cattle grazing on woody encroachment and the composition of native and introduced herbaceous species. In the same coastal grassland, another study experimentally tested the effectiveness of coupling intense prescribed fire with herbicide applications to control mature resprouting woody shrubs. Lastly, we assessed the effectiveness of prescribed fire combined with mechanical-chemical treatments of resprouting woody species in South Texas. Our results suggest that attempts to control undesirable resprouting plant species using dual-treatment combinations of traditional management interventions is not a restoration panacea, but other novel methods of intervention (prescribed extreme fire during periods of drought) may prove ecologically useful and economically pragmatic in addressing problematic resprouting woody plants and restoring degraded rangeland ecosystems.

BARRIERS AND OPPORTUNITIES FOR INCORPORATING NEW KNOWLEDGE INTO RESTORATION DECISION-MAKING.

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Increasingly rangeland managers face questions about when, where, and how to restore burned, invaded, or at-risk lands. Restoration decisions are fraught with many unknowns, which may be ecological, societal, economic, or institutional. Will next spring's weather be suitable for getting seeds to germinate and establish before being overcome by non-native annual grasses? Is enough money budgeted to cover the cost of seeds? Will interest groups try to prevent use of some practices? If I try to restore proactively, how can I be sure my efforts won't just increase the risk of degradation? Researchers respond to such concerns by generating new and hopefully useful information, and tools to make use of that information. However, too often the information generated is not used. This talk explores why this occurs, and how to improve information uptake. Research shows the No. 1 barrier to manager uptake of new science is time to find information, share it with others, and learn how to implement it. There is little a researcher can do to give a manager more time, but we can reduce how much time we require from managers. New tools can make information more accessible and easy to use, and it's important to design such tools to fit managers' time constraints. New data-visualization methods can be valuable if developed in collaboration with managers. Other barriers include the personal and political costs of being wrong. Managers must be reassured that innovation and initiative will be rewarded rather than discouraged or punished, both within and outside agencies. A third category of barrier is regulatory inflexibility. Research suggests citizens agree with managers that more management flexibility and consideration of local contexts are needed, but the political process of providing such flexibility is fraught with difficulty. Overall, support is needed for efforts to make rangeland science "usable."

SEASONAL CLIMATE FORECASTING FOR APPLIED USE IN THE WESTERN US.

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The potential benefits of incorporating seasonal climate forecasts in decision-making are numerous and span multiple sectors. However, many are reluctant to incorporate such information due to skepticism in forecast accuracy and the lack of forecasts distilled at scales or in metrics meaningful for applied use. To overcome these barriers we have statistically downscaled coarse scale seasonal climate forecasts from seven different models participating in the North American Multi-Model Ensemble (NMME) across the western United States. This downscaling allows us to obtain higher resolution (~4-km) predictions of temperature, precipitation, humidity , winds and insolation that are more directly usable than raw output. These data can be incorporated in additional modeling efforts to estimate germination success probabilities, hydrology and fire danger at lead times of up to 7 months. Secondly, we examined the historic forecast skill of these models using hindcasts from 1982-2010. Forecast skill tended to be higher for temperature than precipitation, although significant geographic and seasonal variability was found across models. Likewise, as forecast skill for individual months decreased with lead-time, statistically significant skill was found across over half of the western US for aggregated 3-6 month forecasts. These results suggest that climate forecasts do have the potential to inform decision making, albeit users should make use of forecast skill to decide on how useful they might be. Furthermore, climate forecasts should be treated differently than weather forecasts as model skill was much higher for seasonal aggregations of climate (e.g., accumulated precipitation over the next 6 months) than for specific days, weeks or even months (e.g., monthly precipitation 4 months from now).

GRASS, TREES, DISTURBRANCE, AND THE CONSERVATION OF LESSER PRAIRIE-CHICKENS.

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The lesser prairie-chicken has persisted through the Dust Bowl, vegetation state changes, land runs, oil booms, and introgression with the similar greater prairie-chicken. While it occurs in several distinct vegetation types, it is common in none of them. Despite the plasticity the species demonstrates across space and time, there exist some common factors amongst the various populations. Specifically, these components are the quantity and distribution of grass, trees, and disturbance. While there are knowledge gaps, we largely understand how these primary factors relate to lesser prairie-chickens. Yet, it is whether or not society is willing to compromise that will ultimately determine the fate of a species that has been with us through our entire history on the Great Plains.

PROBLEMATIC C4 GRASSES OF SOUTH TEXAS ASSOCIATE WITH AND POTENTIALLY ALTER ARBUSCULAR MYCORRHIZAL FUNGI COMMUNITIES.

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Many invasive species of the southern and central Great Plains are grasses established to reduce soil erosion and increase hay and forage production on marginal or deteriorated grasslands. Recent studies have indicated arbuscular mycorrhizal fungi (AMF) play an important role in plant invasions as invasive plant species may alter the density and/or composition of AMF communities, promoting the success of invasive species. With many of the problematic species in south Texas being functionally similar to native species, alteration of AMF communities may play a pivotal role in grassland invasions. To determine best restoration practices we must first know the reliance of the native and invasive grass species on AMF and if problematic species are self-facilitating. We conducted greenhouse studies to determine the reliance of four native species, one encroaching, and two invasive species on AMF by planting each species into soil collected from beneath itself that was steamed (eliminating mycorrhiza) or nonsterile (mycorrhizal). We used a "home" vs. "away" approach to evaluate potential feedbacks that may exist between native and problematic species. Our results indicate that plains bristlegrass and pink pappusgrass are obligate mycotrophs, while hooded windmillgrass was facultative, and Arizona cottontop did not respond to AMF symbiosis. The 3 problematic species showed mixed results: buffelgrass was not responsive to AMF while both Kleberg bluestem and tanglehead were obligate mycotrophs. Overall, the "home" vs. "away" studies indicated invasive species may be self-facilitating; native species grew larger in native "home" soil than soil collected from beneath problematic species while problematic species typically grew larger in their "home" soil. Our results also indicate that use of native soil inoculum may hold potential benefits for reestablishment of native grass species following removal of these problematic species.

USING SATELLITE DATA TO ESTIMATE NEAR-REAL-TIME CHEATGRASS PERCENT COVER IN THE NORTHERN GREAT BASIN.

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Every year cheatgrass (*Bromus tectorum*) provides a fine fuel that can ignite and spread fire in shrub steppe environments. Areas where cheatgrass invades experience more frequent fires. However, where cheatgrass exists in a given year is not known until it is encountered in the field, or mapped. Until now, maps estimating cheatgrass extents have not been developed until after a fire season concludes. In this study, we developed an expedited cheatgrass percent cover dataset and map for the Northern Great Basin, two products designed to be available around July 1 of each year. This dataset and map were developed by updating a prior version of a cheatgrass mapping model and are designed to inform land managers and policy makers in near-real-time as they seek to protect grazing allotments and critical wildlife habitat from fire. Producing the expedited cheatgrass percent cover dataset required relatively minor modifications including adjustments to a temporal smoothing process for satellite data, changing start-of-season variables, and substituting an annual summer integration dataset with an 11-year average of summer integration datasets. Comparison of these modified variables to variables used in the previous model revealed strong to very strong results, implying that the 2015 dataset provides a

consistent estimate relative to previous datasets. The expedited 2015 cheatgrass percent cover dataset's values range from 0 to 100 with an overall mean value of 9.85, and a standard deviation of 12.78. The areas of highest consistent cheatgrass percent cover occur in the Snake River Plain. We anticipate future expedited cheatgrass percent cover datasets to be downscaled to 30-meter spatial resolution using Landsat satellite data, compared to the current 250-meter resolution based on the Moderate Resolution Imaging Spectroradiometer (MODIS) sensor.

PLANT HEIGHT AND OTHER FACTORS INFLUENCING BROADCAST HERBICIDE HUISACHE CONTROL.

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Huisache (*Acacia farnesciana*) is a major brush problem in South Texas. Although herbicide individual plant leaf sprays provide very high plant-kill levels (greater than 76%), the same herbicides have not proven reliable when applied as broadcast treatments, either ground or aerial. A fairly specific set of biotic and abiotic indicators are available for broadcast treatments of honey mesquite (*Prosopis glandulosa*). However, similar indicators are not available for huisache. During 2013-2014, aerial and ground broadcast herbicide treatments were applied to 7 sites. Soil temperature and soil moisture were measured at a depth of 12 inches at the time of herbicide application. Plant-mortality was measured at one and two years post treatment. For aerial sites, plant mortality was stratified by height (above and below 7 feet tall). Across all aerial treatments, plant mortality was significantly greater ($p=0.000158$ and $p=0.000198$) for plants under 7 feet tall during 2013 and 2014, respectively. For 2013 sites, there was a linear relationship ($r2=0.99$, $p=0.025$) between soil moisture and two-year plant mortality. Across all ground broadcast treatments, 2013 plant mortality was significantly greater ($p=0.0208$) than 2014. Soil moisture at application was 8 versus 2 (0 to 10 scale) for 2013 and 2014, respectively.

ARE CATTLE SURROGATE WILDLIFE? SAVANNA PLANT COMMUNITY COMPOSITION EXPLAINED BY TOTAL HERBIVORY, NOT HERBIVORE IDENTITY.

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The replacement of wild ungulate herbivores by domestic livestock in African savannas is composed of two interrelated phenomena: 1) loss or reduction in numbers of individual wildlife species or guilds, and 2) addition of livestock to the system. Yet very few studies have addressed the individual, combined, and potentially interactive effects of the presence and absence of wild versus domestic herbivore species on herbaceous plant communities within a single system. Additionally, there is little experimental evidence addressing the question of whether, and in which contexts, livestock might functionally "replace" native herbivore wildlife. The Kenya Long-term Exclosure Experiment (KLEE) has since 1995 manipulated access by different replicated combinations of mega-herbivores, meso-herbivore ungulate wildlife, and cattle in a wooded savanna ecosystem. Herbaceous vegetation was sampled 25 times between 1999 and 2013 in

each of the eighteen 4 ha KLEE plots. We found evidence for additive effects of the resident community of wild ungulates (which included grazers, browsers and mixed feeders) and cattle (mostly grazers) on herbaceous community composition. Our results suggest that overall herbivory pressure, rather than complex interactions among different types of herbivores, drove the dominant trends in plant community dynamics. Differences between cattle and wild ungulate impacts on the herbaceous layer of this savanna ecosystem may be related more to the higher density of cattle than to differences related to species-specific, per-animal impacts. Additionally, although our results suggest considerable functional similarity between a suite of native wild herbivores (spanning different feeding guilds) and domestic livestock with respect to understory plant community composition, responses of individual plant species demonstrate that at the plant population level, impacts of a single livestock species are not functionally identical to those of a diverse group of native herbivores.

THE INFLUENCE OF SOIL COLOR ON SEEDBED MICROCLIMATE AND SEEDLING DEMOGRAPHICS OF A PERENNIAL BUNCHGRASS.

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Perennial bunchgrasses are critical to maintaining sagebrush plant communities but seeding of native bunchgrasses following fire has met with only limited success. Previous research indicates that blacked soils beneath burned sagebrush canopies have increased seeding success for perennial bunchgrasses when compared to interspace locations. We investigated soil moisture and temperature across white, brown, and black soils and tested the relationship between soil color and seedling demographics for seeded bluebunch wheatgrass. We used a randomized block design with three treatments and five replications conducted in a Wyoming big sagebrush community in southeast Oregon. The study site was roto-tilled prior to establishing 50 x 50 cm plots in each of two years. We installed soil temperature/moisture probes at two cm depth in each plot. Plots were seeded in November of each year with 250 viable bluebunch wheatgrass seeds. Plots were then covered in a < 1mm layer of white, brown, or black aquarium sand and sand was re-applied as needed over time. We counted emergent seedlings weekly from snowmelt through May of the year following planting. Soil moisture during the emergence period (March – May) was highest for white soils and lowest for black soils ($p < 0.05$); soil temperature was highest for black soils and lowest for white soils ($p < 0.05$). Year one was characterized by a warm and dry emergence period and year two was relatively cool and moist. Emergent seedling density was highest ($p < 0.05$) for white soils; surviving seedling density (on June 1) was highest ($p < 0.05$) for white soils in year one and black soils in year two. Black soils had greater success in a year with lower soil temperatures and adequate soil moisture. When soil moisture is limited, increased soil temperature on black soils led to seedling desiccation and death.

TEMPERATURE, CLIPPING, AND DROUGHT EFFECTS ON BELOWGROUND BUD OUTGROWTH OF SMOOTH BROME AND WESTERN WHEATGRASS.

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Plant population persistence throughout the Great Plains, especially of perennial grasses, is dependent on tiller recruitment from the belowground bud bank. In the northern mixed-grass prairie of the Great Plains, plant communities often include the native rhizomatous grass *Pascopyrum smithii* (western wheatgrass) but are increasingly invaded by the non-native rhizomatous grass *Bromus inermis* (smooth brome). Differential bud outgrowth responses of these species to temperature, soil moisture and clipping could alter their competitive interactions and impact native grassland resiliency to climate change. Bud outgrowth from tillers of both species was evaluated under three spring temperature regimes (Average: 12ºC 18ºC and 24ºC) and two soil moistures (short-term drought and well-watered) in a series of two-week growth chamber experiments. The response of western wheatgrass bud outgrowth to clipping was also examined. Smooth brome had more buds per tiller and initiated a greater proportion of these buds than western wheatgrass under all temperature and moisture conditions. Western wheatgrass bud development was reduced at 24ºC. Short-term drought did not significantly impact bud outgrowth of either species. Clipping increased western wheatgrass bud mortality and reduced its bud development. The robust vegetative reproductive capacity of smooth brome under a range of environmental conditions is a key mechanism enabling the expansion of smooth brome into northern mixed-grass prairie in North America. Because of the negative impact of clipping on western wheatgrass bud outgrowth, mixed-grass prairie dominated by western wheatgrass may require longer recovery times, especially in areas susceptible to smooth brome invasion. Resiliency of mixed-grass prairie to the separate and interactive effects of climate change, non-native perennial grass invasions, and repeated defoliation depends upon successful tiller recruitment and establishment of native perennial grasses via the bud bank.

NAVIGATING YOUR FUTURE AS A RANGELAND PROFESSIONAL.

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This workshop is to help inform, invigorate and inspire the up and coming rangeland professionals of today's world. We want to help young rangeland professionals understand the future of our industry, required skill sets, what potential employers are looking for in new hires now and how the Society of Rangeland Management and the Young Professionals Conclave can help. Almost 15 years have passed since a series of articles came out in Rangelands talking about the future of rangeland professionals and rangeland science. These articles demonstrated the need to advance range science by incorporating other disciplines and better understanding of the constituents using the land. In June of 2012 Rangelands published a special issue on learning and teaching rangeland science to help improve and prepare students, teachers and federal employees for the demands of range science today. Rangeland science has always been interdisciplinary but today it is necessary that we prepare the future rangeland professionals for their careers whether it is as a land manager, consultant, researcher, extension agent/educator or rancher by providing the best science and policy information to help them succeed.

Our workshop will provide up-to-date information on how students and young professionals can be successful in a field in rangeland science and ecology. Participants will be provided opportunities to learn from and interact with successful rangeland professionals from consultancies, federal government, ranches and academia along with members of the SRM Board of Directors and YPC.

FALL SEEDING TO REDUCE WHITETOP (*CARDARIA DRABA*) ABUNDANCE: A COLLABORATIVE RANGELAND MANAGEMENT EXPERIMENT.

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Research can play an important role in generating useful information for rangeland managers. However, the "how" in linking research with the information managers need is not well described. *How* does one practically design research that generates information that is relevant and applicable to managers? And how to do this while ensuring adequate replication, sample size and monitoring given limited resources? This presentation details one such example from a small-scale experiment in northwestern Colorado on seeding strategies for managing whitetop (*Cardaria draba* (L.) Desv.). Local land managers, ranchers, and researchers worked together to collaboratively define a local issue of interest, brainstorm potential treatments that would be feasible, and implement treatments in an applied, experimental framework. The group chose to determine the effects of broadcast seeding native and non-invasive grasses, with and without harrowing, on native grass establishment and whitetop abundance following the application of chemical herbicide to reduce whitetop. We expect that this experiment will inform the evaluation of costs and benefits of seeding treatments in infested areas. Treatments were applied in the fall of 2014 in two, 29.2 m by 14.6 m blocks that were each divided into 6 plots each. We applied each treatment to 2 plots per block for a total of four replications. The remaining 2 plots per block were used as non-seeded, non-harrowed controls. We monitored canopy cover and density by functional group before and after applying treatments. Here we present results from two years of monitoring of the effectiveness of treatments. We also describe the learning outcomes for the researchers, managers and ranchers involved in the experiment. This experiment is one example of a collaboration that engaged the skills and experience of managers and researchers to develop knowledge for manager-defined natural resource issues.

LONG-TERM PRECIPITATION PATTERNS ASSOCIATED WITH FUELS, FIRE, AND POST-FIRE RESTORATION SUCCESS IN THE GREAT BASIN.

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Fire is causing an unprecedented loss of sagebrush steppe habitat across the Great Basin. To slow and reverse this trend, increased emphasis is being placed on wildfire prevention and suppression and post-

fire restoration efforts. We examined how multi-year precipitation patterns influence fire occurrence and post-fire treatment success in sagebrush habitat throughout the Great Basin. Our dataset consisted of over 15,000 fire occurrences (1950-2014), 2,200 post-fire seeding projects (1951-2014), and 114 years of monthly modeled precipitation data specific to each fire and seeding project. Preliminary results suggest that more and larger fires tend to burn when 2-3 years of above-average precipitation are followed by a sharp drop to normal or below-average precipitation. Several years of high precipitation likely increases herbaceous vegetation, which then accumulates into high fuel loads (e.g., dense litter). More surprisingly, post-fire seeding treatments in the fall or winter after a fire often occur when precipitation is below average for the area, possibly contributing to lower than expected germination and seedling survival. Post-fire seeding success was more likely at sites where precipitation returned to average or above average levels within the first 1-2 years after fire. The strength of these patterns varied across different regions of the Great Basin, but overall, our preliminary findings suggest that allowing more flexibility in the timing of post-fire seeding (to avoid multi-year droughts) or permitting multiple seeding efforts (to sow different species at different times or reseed after failed attempts) may be a first step towards increasing success rates. Examining longer term precipitation patterns and using fall-early winter precipitation data could also help land and resource managers predict areas of high wildfire probability (and thus suppression resource need) and areas where treatment implementation could be delayed to maximize restoration effectiveness.

RANGELAND ECOHYDROLOGY: ADVANCES AND MANAGEMENT IMPLICATIONS.

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The past quarter century has seen impressive advances in our understanding of ecohydrological processes on rangelands and how these processes are affected by management policies. New research has provided a much clearer picture of water dynamics on rangelands (amounts and timing of both green and blue water) and how these fluxes are affected by biota. This greater understanding has been made possible not only by the sheer number of new studies but also by new observational methodologies, particularly with respect to remote sensing and the use of stable isotopes. In addition, new conceptual and theoretical approaches as well as increases in computational power have significantly improved our ability to predict and model ecohydrological processes. The three advances that we highlight relate to (1) spatial variability and scale, (2) ecosystem thresholds and feedbacks, and (3) hydrological connectivity of landscapes. New insights in conceptual and theoretical approaches are providing a better framework with which to interpret the higher resolution data collected using newer technologies. We expect that the near future will bring further developments in observational techniques and computational power, paving the way for more new and exciting insights into the ecohydrology of rangelands.

DEVELOPMENT OF INDICES TO SELECT GRAZING BEEF CATTLE FOR TERRAIN USE.

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Genetic markers (genotypes) were recently associated with indices of terrain use (phenotypes) in grazing beef cattle. These indices were based on the ratio of a cow's average terrain use and average slope, elevation and horizontal distance to water of its contemporary group (cattle in the same pasture during the same time period). Ratios weighted the impact each metric of terrain use (slope, elevation or distance to water) equally even if a metric would not be expected to affect grazing distribution. Although ratio-based indices worked well, ratios are not effective metrics for calculating breeding values needed for genetic selection. Estimated progeny differences (EPD; a common method of comparing bulls during selection) use metrics with measureable units while ratios are dimensionless. Using published research, we estimated the time cows would graze a location based on slope and horizontal and vertical distance from water. The new index is the time cows spend in areas they are not expected to graze. Preliminary evaluations indicate that the developed indices can be used to compare terrain use of cows in different locations. In rolling terrain, developed indices were highly correlated ($r > 0.8$) to ratio-based terrain indices, but in mountainous terrain developed indices were moderately correlated ($r = 0.3$ to 0.4) to ratio-based terrain indices. Prior research may have underestimated grazing use of areas that are far horizontally and vertically from water at some ranches. Potentially we can adjust published relationships between forage utilization and terrain attributes using GPS tracking data and improve accuracy. Another obstacle in development of these indices is assigning the relative importance of slope and horizontal and vertical distance to water to the indices. In summary, indices that are direct numeric estimates of the traits appear to be more effective than ratios in predicting grazing use of beef cows in mountainous terrain.

AN AGENCY SUCCESS STORY: NURTURING OF PARTNERSHIPS FROM ALL SIDES OF THE STREAM!

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In 2009 a riparian restoration project was scheduled to be implemented in the Wigwam Creek drainage in the Gravelly Mountains of Southwest Montana on the Beaverhead Deerlodge National Forest, Madison Ranger District. This project, while well intentioned, was missing a crucial component; the involvement of the allotment permittee. Although funding had been secured and improvement sites located and mapped out, the project was inevitably put on hold. In 2010, a meeting between the permittee, Range Management Specialist, and Fisheries Biologist was held. Once the permittee was involved, a vested interest was developed, a consensus was reached, and the Wigwam Project was again under way. This project had many components; waterlines, troughs, fencing, livestock, and native trout….but most importantly, a partnership forged among an unlikely cast of characters. In spite of an atmosphere of distrust between the ranching community, government agencies, and conservation minded organizations, they were able to work together to complete the project. This is the real story, although range improvements and stream restoration are the tangible results, it is this meeting of the minds that is by far the true "Agency Success Story" that we would like to share.

LONG-TERM IMPACT OF TARGETED GRAZING ON NATIVE BUNCHGRASSES AND ANNUAL GRASSES.

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Wildfires have caused concern as they have increased in severity and intensity over the last few decades. Land managers have sought management actions to mitigate the risk of wildfire by reducing fuel loads, thus decreasing wildfire intensity. Camp Williams is a National Guard training facility near Bluffdale, Utah that is used for artillery and light arms training. Managers at Camp Williams have created fuel breaks as part of their wildfire mitigation plan. They have implemented targeted sheep and goat grazing to remove fine fuel and thin brush. Management objectives set utilization of fine fuels (grass) at 80% by weight. Questions arose as to what the ecological impact are of managements prescribed grazing rates within these fuel break. We evaluated three fuel breaks and quantified the impacts of targeted sheep and goat grazing at 80% utilization. We assessed how invasive annual grasses, such as cheatgrass (*Bromus tectorum*) and bulbous bluegrass (*Poa bolbosa*) responded to heavy utilization rates. During the summer of 2015 we collected herbaceous cover, shrub density and bunch grass density along eight paired (inside fuel break and outside fuel breaks) transects. Our results indicate that the current management grazing plan could lead to an increase of invasive annual grasses, which may be counterproductive in fuel breaks. Our results suggest that changes in timing or intensity may be needed. This information will assist managers in fine tuning targeted grazing as a fuels reduction tool to create fuel breaks.

A CALL FOR QUALITY: THE ROLE AND IMPORTANCE OF QA AND QC IN RANGELAND MONITORING PROGRAMS.

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Producing quality data to inform land management decisions is the goal of every rangeland monitoring program, however the exact role of quality assurance (QA) and quality control (QC) in this process is rarely discussed. The purpose of QA and QC is to prevent and describe non-sampling errors, 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. We explored the QA and QC protocols of prominent rangeland, forest, and aquatic monitoring programs across federal agencies (BLM, USFS, NRCS, EPA) to develop a list of best QA and QC practices that are reasonable given the cost and efficiency constraints of most rangeland monitoring programs. Common QA practices include careful design of the monitoring programs; training and calibration of data collectors; and management of resulting data. The quantification of QC errors includes automated data checks, variance decomposition, and evaluation of signal-to-noise ratios. As a result, we present a list of practices and standards that yield an acceptable quality of data without overburdening data collectors or monitoring program managers. These practices should be implemented regardless of scale to ensure consistent, quality data for any type of rangeland monitoring.

USE OF SAINFOIN IN PURE AND MIXED STANDS WITH ALFALFA UNDER DIFFERENT HARVEST REGIMES.

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Alfalfa (*Medicago sativa* L.) is a forage species that is widely used in Canada but it causes bloat in cattle. Sainfoin (*Onobrychis viciifolia* Scop.), a condensed tannin containing legume does not cause bloat and in mixtures with alfalfa prevents bloat in grazing cattle. However, sainfoin cultivars developed for western Canada do not persist in alfalfa stands for long and do not regrow at the same rate as alfalfa in newly developed mixed stands. Nova sainfoin and three new sainfoin populations (3900, 3901 and 3902) were seeded in 2008 as monocultures and in mixtures with alfalfa, AC Grazeland at the Agriculture and Agri-Food Canada - Swift Current, Saskatchewan in the semiarid region of western Canada under rain-fed conditions to determine biomass yields and stand longevity under single cut for stockpile use or multiple cuts for pasture grazing or haying. Alfalfa and sainfoin were seeded in small plots (5 m x 5 m) to achieve a 50:50 proportion in the mixtures using a seeding rate of 5 and 15 kg ha-1 respectively. Mean DM yield of Nova sainfoin in five production years (4060 kg ha-1) was higher ($p<0.01$) than yields of the new sainfoin populations (3100 – 3300 kg ha-1) under the multiple cuts and also under single cut (2700 v 2000 kg ha-1). DM yields of alfalfa/sainfoin mixtures were 10 – 20% higher than the monocultures under both harvest regimes. DM yields in all stands were higher ($p<0.01$) under multiple cut regime than single cut in all production years. DM percent of sainfoin in mixed stands declined with age of stand but vigour of sainfoin under both harvest regimes were similar. The alfalfa/sainfoin mixtures may help improve pasture and hay production as well as stockpile hay in western Canada.

STRATEGIC GRAZING MANAGEMENT, COMPLEXITY, DISTRIBUTION, AND ANTI-PREDATOR BEHAVIOR.

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Strategic grazing management involving high stocking density and frequent movement, such as rotational grazing and herding with low-stress livestock handling, can—if well planned and creatively managed— improve rangeland health and livestock production, by managing the distribution of grazing across time, space, and plant species. Authors in the sponsored issue of Rangelands on Strategic Grazing Management for Complex Creative Systems (Barnes and Hild 2013) discussed key processes and management actions that determine the extent, timing and direction of responses to grazing management. For instance, strategic multi-paddock grazing can be used to shift utilization from riparian areas to steeper uplands, and to less desirable plants, increasing the grazing capacity (Barnes and Howell 2013). Similar benefits may be possible with low-stress herding, though perhaps not to the same degree (Barnes 2015a). The central anti-predator behavior of wild grazing animals is to form large, dense herds that then move around the landscape to seek fresh forage, avoid fouled areas, and escape predators. Evidence synthesized from the rangeland, wildlife, and animal sciences suggests that modeling livestock management after the grazing patterns of wild ungulates in the presence of their predators can increase the ability of ranching operations to coexist with native carnivores (Barnes 2015b).

DENSITY-INDEPENDENT NUTRITIONAL LIMITATIONS TO LARGE UNGULATE POPULATIONS: WIDESPREAD AND IMPORTANT OR RARE AND INCONSEQUENTIAL?

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Density-dependent negative feedback relationships between populations and the forage available to them have long served as a foundation for large ungulate population ecology and habitat management in North America. However, increasing evidence suggests that density-independent relationships between large ungulates and nutrition also exist during summer, that these may significantly limit reproduction and population growth, and that these limitations may be more common than often believed. We consider our data collected on elk in the western US and on caribou in Canada, along with findings from a variety of studies, to discuss ecological attributes that may contribute to density-independent, nutrition-based limitations in summer. Density-independent limitations are increasingly documented in arid, highly stochastic environments but our data suggests they may also occur in forest ecosystems where nutrient content (mainly digestible energy) and/or forage abundance (through instantaneous and daily intake rates) fail to satisfy nutrition requirements of lactating females. Although the data remain indirect, we conclude that ecological characteristics in some settings can be responsible for inadequate forage quality or quantity, regardless of ungulate population density (i.e., density-independent nutritional limitations), and that greater understanding of relationships between ecological conditions, forage quality and quantity, and ungulate population dynamics should lead to better management of habitat on behalf of large ungulate populations in many areas of North America.

RESPONDING RATIONALLY TO UNCERTAINTY: STOCKING RATE DECISIONS TO COPE WITH CLIMATE VARIABILITY.

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The loss of rangeland ecosystem function (health) is most often attributed to an imbalance of forage supply and demand. As changes in atmospheric chemistry increasingly drive climate variability and production, most rangeland-based livestock grazing systems are predicted to be increasingly difficult to manage. A central tenet of rangeland management has always been the establishment of a sustainable stocking rate (based on carrying capacity) and adjustments to that stocking rate based on annual growing conditions. Reduced forage production was typically either tolerated (temporarily reduced animal performance) or mitigated (supplemental feeding). When forage production was greater than anticipated, managers either acquired more grazing animals or diverted excess forage to other uses (hay, fuel, range improvement). An inability to respond quickly enough by adjusting animal numbers can either result in degradation or missed opportunities. In this workshop, we will examine historical evidence for improving stocking rate decisions, prediction tools that might be helpful in making stocking rate decisions and discuss the application of these concepts and tools to different ecosystem and livestock operations.

ECOLOGICAL SITES: PROVISIONAL PLANS AND STRUCTURAL HIERARCHY.

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Ecological Sites (ES) have been official policy of USDA NRCS as a basis for resource inventory and assessment and conservation planning since 1997. They have also been implemented to varying degrees by USDI-BLM and USDA-FS since the early 2000s. While there has been substantial progress in both concept and application, the effort lacked consistency. That inconsistency diminishes credibility and weakens the ability of a wide variety of users to learn from the collective information, test important hypotheses and confidently create new applications. In early 2015, NRCS adopted a Provisional Ecological Site (PES) Initiative intended to complete an initial inventory of ES in the contiguous U.S. by 2020. The initiative calls for the organization of soils and vegetation data at the Major Land Resource Area (MLRA) scale. Each MLRA is considered completed only when all described soils are organized into an ES key and initial State and Transition Models (STM) are completed and reviewed. Generalized STMs and associated information provide sufficient evidence for site specific inventory and establishing management objectives, identifying important ecological processes and selecting appropriate conservation practices. As a complementary endeavor, MLRAs are being updated to quantify climate, geology, soil and land use attributes and reconcile with commonly used land classification systems.

LOW-STRESS HERDING FOR COEXISTENCE WITH LARGE CARNIVORES IN THE NORTHERN ROCKY MOUNTAINS.

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People and Carnivores, Bozeman, MT

Strategic grazing management is based on the patterns of wild grazing animals in the presence of their predators, which tend to increase group size (comparable to stock density) and movement over landscapes (comparable to grazing management). Managing livestock based on these patterns, especially with low-stress herding, appears to reduce predation losses. Partnering with progressive ranchers, we field-tested approaches to herding cattle at relatively high stock density. In western Montana, we applied two close herding methods. First, we used night penning and daily herding to enforce constantly high stock density. Then, we used low-stress herding to train the co-mingled heifers to function socially as a single herd. Low-stress herding required more skill, and significant initial labor, but less labor overall. In a second project, at the beginning of the grazing season, with a herd of co-mingled steers, we combined daily low-stress herding with night penning, to maximize stock density when potential predators would be most active and to impact portions of the pasture that were otherwise under-utilized. Increased herd instinct lasted beyond the daily herding period, throughout the summer grazing season. The yearlings apparently did not interact with potential predators in either of these projects. A year after the second project, areas where we night-penned cattle had up to 55% more forage production than adjacent areas grazed at moderate stock density. In northwestern Wyoming, we

provided training in low-stress livestock handling for permittees on a National Forest allotment with two herds and a history of losses to predation by grizzly bears and wolves. One of the two herds showed consistent herd instinct, and one showed slightly improved herd instinct. During the first two years, there have been no confirmed predation losses. Herding appears to potentially reduce both encounters with large carnivores and the likelihood that such encounters result in predation.

GRASSLAND BIRD NEST SITE SELECTION AND SURVIVAL IN RELATION TO PYRICHERBIVORY IN SHORTGRASS STEPPE.

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Patch burn grazing management (pyricherbivory) has been recommended as a management tool to generate a heterogeneous vegetation mosaic for grassland birds. In shortgrass steppe of the western Great Plains, patch burns provide breeding habitat for the mountain plover (*Charadrius montanus*), a grassland bird of conservation concern, but consequences for other bird species are unclear. We examined the nesting ecology of 3 passerine species in relation to pyricherbivory in northeastern Colorado. Lark buntings (*Calamospiza melanocorys*) selected nest microsites with greater cover of midgrasses and shrubs, and nest microsites occurred in patches (200 m radius) with greater vegetation height compared to the overall landscape. Lark bunting abundance was low in recent burns, and most nests (91%; *N* = 23) occurred in areas not burned in the past year. In contrast, McCown's longspurs (*Rhynchophanes mccownii*; *N* = 132) and horned larks (*Eremophila alpestris N* = 54) selected nest microsites with greater height and cover of midgrass and cactus, and nests were located in patches (200 m radius) with shorter height, less midgrass and less shrub cover than the overall landscape. Both species were equally abundant on versus off current-year burns. To assess effects on reproductive performance, we examined nesting survival across a time-since-burning gradient. The most parsimonious model for nest survival, after accounting for nest age, time in season and species, also included seasonal temperature (β = -0.236 + 0.098), current day precipitation (β = -0.041 + 0.020), dry conditions the prior day(β = -1.201 + 0.797), and the amount of midgrass and shrub cover within 200 m of the nest (β = -0.083 + 0.051), but did not explicitly include time since burning. Thus, weather and vegetation structure influenced nest survival of McCown's longspurs and horned larks, but vegetation conditions that enhanced nest survival occurred both in burned and unburned shortgrass steppe.

DO METABOLIC RATES OF BEEF CATTLE TRACK STEP-WISE CHANGES IN FEEDING LEVEL?

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In Montana, most beef cattle *Bos taurus* are fed hay for 3-5 months each winter, which is typically a rancher's highest variable cost. Without feeding, beef cattle may lower their metabolic rates (MRs) while grazing winter range, similar to wildlife, without impacting reproductive performance. Our objective was to determine if MRs of beef cattle track short-term step-wise decreases, then increases in feeding level. Over a 30 day period, we measured MRs (based on O2 consumed) and respiratory

quotients (CO2 respired/O2 consumed) of six non-pregnant, non-lactating Black Angus cows. Initially, cows were fed chopped hay (7.5% CP) *ad libitum* for 16 days to determine full feed (100%). Beginning on d 0, three cows were exposed to a Moderately Restricted (M) feeding level (110%>110%>55%>110%>110%), three cows were exposed to a Restricted (R) feeding level (110%>70%>35%>70%>110%) in four-day increments. Metabolic rates of all cows were measured the morning after each four-day, step-wise decrease and increase in feeding level. Metabolic rates tracked feeding level. As expected, respiratory quotients declined as feeding levels declined indicating that cattle were catabolizing fat. Overall, these results suggest that cattle entering winter in good body condition which are not fed hay during winter, but just graze, may conserve energy by lowering their metabolic rates. Alternatively, ranchers who feed hay to their cattle during winter may be unnecessarily maintaining elevated metabolic rates at great expense.

STATES AND TRANSITIONS IN ASPEN DOMINATED ECOSYSTEMS OF WESTERN COLORADO.

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Across the western United States aspen stands are valued as areas of relatively high forage production, excellent native ungulate habitat, and sources of aesthetic value. Aspen decline is a major concern to many ranchers and land managers in Colorado. We partnered with landowners and land managers in western Colorado to develop state-and-transition models specific to aspen stands occurring within the areas in which these individuals live and work. The process of working with land owners and land managers to develop locally-relevant STMs for these systems led us to ask the following research questions: 1) What aspen stand functional types are present in the study areas? 2) Do aspen stands in the study areas occur on one ecological site or across multiple ecological sites? 3) Is the severity of aspen die-off correlated with abiotic site characteristics that distinguish specific ecological sites? 4) Are levels of herbivory, root density, or suckering positively or negatively correlated with foliar cover and the proportion of live/dead trees in a stand? We surveyed soils and vegetation on 21 plots in aspen stands and 21 plots in adjacent non-aspen vegetation communities. These paired aspen and non-aspen plots are located within the same soil map units (as identified by the National Conservation Service's Web Soil Survey) and within similar slope ranges. We conducted community classification and ordination using nonmetric multidimensional scaling, multi-response permutation procedures, and indicator species analysis. We describe how the results of these analyses are applied to create more locally-relevant STMs for aspen-dominated ecological sites.

EFFECTS OF ANIMAL BEHAVIOR ON BODY CORE TEMPERATURE AND PRODUCTION EFFICIENCY OF GRASS FINISH CATTLE.

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Ruminant production efficiency is affected by the voluntary intake of forages and forage quality. Increasing foraging activity increases energy requirements of animals. Frame size and physiological status also influence energy requirements. Forage quality changes with daily and seasonal fluctuations in temperature and light intensity. Production efficiency of grass-finished cattle may be influenced by these factors. Previous studies show that high quality grass-finished beef can be grown on Hawaii pastures. However, the nutritional quality of consumed forages, such as C4 grasses, have not been evaluated as it pertains to grass-finish beef production. Identifying factors that influence the efficiency of grass-finished beef production would be valuable information. A two-year study was conducted on 24 grass-finished cattle at the University of Hawaii, Mealani Agricultural Experiment Station. Animal behavior, BCT, weather variables, and forage quality were assessed during three daily periods (am, noon, pm) over three seasons. Cattle grazing activity was highest during the morning and evening periods compared to the midday for all seasons. Cattle spent the least amount of time laying down; a time when their BCT was highest. Standing and chewing and standing activity were higher during the midday in all seasons but highest in summer. Forage quality varied seasonally and was highest in summer than in fall. Diurnal differences were observed in the carbohydrate values which were highest in the evening through all seasons. Average Daily Gain (ADG) was not significantly greater between the 2012 cohort (0.86 kg/d) and 2013 cohort (0.84 kg/d). All animals were slaughtered at an average of 20 months and a live body weight of 531 kg. Eighty-percent of carcasses graded choice or better. Results from this study provide insight into the influence of forage quality and BCT on grazing behavior and production efficiency and may lead to improved management practices for grass-finished cattle.

UNDERSTORY RESPONSE TO PRESCRIBED FIRE AND GRAZING IN WOODY-ENCROACHED OAK SAVANNA.

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Encroachment of woody plants into savanna understories changes vertical structure of biomass, reduces herbaceous vegetation and alters savanna fuelbeds. Oak savanna occurs globally and is characterized by old-growth oak (Quercus spp.) stands and herbaceous understory. Previous land-use and management can allow woody vegetation to dominate the understory and degrade these dynamic ecosystems making control a primary objective of fire and grazing management. We used terrestrial laser scanning (TLS) to estimate understory biomass and to model vertical structure across four treatments: burned, grazed, burned/grazed and unburned/ungrazed at the Sherburne National Wildlife Refuge in central Minnesota. We used TLS because, unlike conventional techniques, it can quantify changes in understory vegetation and vertical distribution of biomass rapidly, non-destructively and with fine detail. We discuss understory response to treatments and compare the relative effectiveness of fire, grazing and fire and grazing together in reducing woody understory.

INSTITUTIONAL ANALYSIS OF SCIENCE GENERATION AND DISSEMINATION IN RANGELAND DROUGHT MANAGEMENT IN TEXAS AGRILIFE AGENCIES.

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Range science, as an applied discipline, aims to provide useful information for land managers regarding how they can improve their land management, yet there are few studies examining how the process of knowledge production and dissemination in range science influences the kinds of knowledge available for land management. In this study we conduct an institutional analysis of the process of knowledge flow between researchers and extension staff within Texas A&M University's Agrilife agencies regarding drought management in rangeland ecosystems. Drawing on semi-structured interviews with key informants involved in generating and disseminating knowledge regarding drought management in Texas rangelands, we examine the process through which research questions regarding drought management in Texas rangelands are defined by research staff, how the findings are shared with extension staff, and how extension staff communicate research needs to research staff. We find that there are significant institutional barriers that obstruct knowledge flow in both directions: scientists define research agendas primarily in response to the needs of funders and scientific publishing outlets that are not driven by a need to generate actionable knowledge, while the dispersed nature and limited budgets of extension staff prevent them from effectively gaining access to knowledge and communicating knowledge needs. We also use detailed case studies to examine situations in which these barriers can be overcome.

SUCCESSFUL COLLABORATION FOR COLUMBIA SPOTTED FROG CONSERVATION IN NORTHERN NEVADA.

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In 1993, the US Fish and Wildlife Service (USFWS) classified the Columbia spotted frog (*Rana luteiventris*) as a "candidate" species because of apparent small population size, habitat deterioration, and imminent threats. From 1999-2002, a Columbia Spotted Frog Technical Team, comprised of several cooperating entities including the USFWS, Nevada Department of Wildlife, Bureau of Land Management, US Forest Service, Nevada Natural Heritage Program, and University of Nevada Cooperative Extension, worked together to write a conservation plan for this species. Upon signature approval in 2003 by these same entities, a 10-year Columbia Spotted Frog (Northeast Nevada Subpopulation) Conservation Agreement and Strategy was implemented. During this time (2003-2013), the Technical Team was charged with plan implementation, evaluation, and strategy revision as necessary. Inventory and monitoring activities by this team and a similar central Nevada team served to increase knowledge of spotted frog distribution, populations, and habitat. Results of this effort were at least partially responsible for a 2007 recommendation by the USFWS that an emergency listing of this species was not warranted, and that the listing priority be down-graded from a category 3 to a category 9. During 2013, the USFWS concluded in its annual Candidate Notice of Review that "*Extensive surveys and monitoring since 1993 have revealed that Columbia spotted frog populations within the Great Basin DPS* [distinct population

segment] *are more widespread and common than previously known."* Implementation of several habitat enhancement projects identified in the Conservation Agreement and Strategy has benefitted Nevada populations of this species, and a new 10-year plan was written and signed in February 2015 by the original signatory parties and others. On October 7, 2015, the FWS determined after analysis of the best available scientific data that the Great Basin DPS of the Columbia spotted frog did not warrant federal protection under the Endangered Species Act.

FUNDING MOST LIMITS OUR ABILITY TO CONTROL MEDUSAHEAD IN NORTHERN UTAH.

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As part of an interdisciplinary research project during 2012-2015 we sought to identify and rank key factors that most limit the ability of stakeholders to control the spread of medusahead *(Taeniatherum caput-medusae)* in southern Cache County. Part of the local scene for over 20 years, medusahead has been viewed as a chronic and potentially dangerous adversary that has largely defied eradication efforts. We considered technical, economic, social, and institutional factors in our qualitative analysis. We used a multi-method approach founded on focus groups and interviews with stakeholders that included weed researchers, agency land-management personnel, and various landowner groups. While the final data set was patchy, it was sufficient to complete our objective. Overall, low and irregular funding emerged as the key factor most limiting progress for both applied research and outreach. Considerable study is still required to identify best practices for medusahead control with respect to herbicide application and vegetation manipulation; this requires higher levels of support than have been typical. Lack of an effective technical package for adoption by landowners remains the single biggest stumbling block; no package equals less landowner interest. Control efforts have been dominated by risky and sometimes costly seat-of-the-pants approaches; these result in stakeholder apathy. Adequate funding is also needed to attract and retain high caliber, well-trained "weed outreach coordinators" who can effectively engage the public and maintain programmatic continuity. A secondary factor of importance is the high degree of socio-economic heterogeneity in the study area; a weed coordinator must rally a critical mass of landowners to undertake weed control across the landscape; adjacent landowners may not share common views as to the nature or urgency of weed-related problems. Finally, institutional matters did not emerge as a constraint in our analysis. Weed professionals only reported positive experiences concerning their collaborative, inter-agency efforts to help control weeds.

HABITAT-SUITABILITY BOUNDS OF WOODY COVER FOR NORTHERN BOBWHITES.

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Woody vegetation is an important component of northern bobwhite habitat. Woody plants are widely used by bobwhites for loafing, escape cover, thermoregulation, and food. Several researchers have

provided recommendations for optimal amounts of woody cover required by bobwhites, and their suggestions have often differed substantially. Discrepancies in these recommendations could be an artifact of inconsistent research methodologies, differences in the scale of measurement, or the ability for bobwhites to interchange the use of habitat components, a concept also known as *slack*. The objectives of our study were to quantify (1) the relationship between woody and herbaceous cover at bobwhite locations and (2) to quantify woody cover used at 3 different spatial scales (point-of-use, home range, and pasture scale) by bobwhites. Our study occurred from April-August (2014-2015) on 5 ranches in Goliad, Zavala, Real, and La Salle Counties in South Texas. Radio-marked bobwhites were located three times per week, and their locations were taken with a handheld GPS. Vegetation data was recorded at bobwhite and paired, random locations. Spatial data, such as woody cover within bobwhite home ranges and pastures, was analyzed in ArcGIS. From our first year of data, mean percent woody cover was greater at bobwhite locations (55%) compared to random locations (36%), however, mean percent herbaceous cover was similar between bobwhite locations (34%) and random locations (35%). Woody cover had a stronger effect on habitat use than herbaceous cover, but optimum use occurred when intermediate amounts of both were present. This research will allow bobwhite managers to refine brush management for bobwhites based on spatial scale and the amount of herbaceous cover present.

SPRING DEVELOPMENT - LESSONS LEARNED.

Lou Hagener*

retired BLM, Havre, MT

Developing springs on rangeland is a long tradition. Early on, springs were developed for human needs or to accommodate livestock. There are multiple resource values to springs some of which are improved or damaged by development. In developing and updatings springs it is important to recognize capabilities of the spring and how the water from the spring will be used and multiple values of the original and developed spring. Many designs have been used and have advantages and disadvantages. The presentation will discuss lessons learned in develoment of springs including collection setups, delivery pipelines, tank setups, maintenance and water management as well as protection of the integrity of the spring.

YELLOW FLAG IRIS STOMP: FFA STUDENTS DANCING TOWARDS INVASIVE WEED MANAGEMENT IN WETLANDS.

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Yellow Flag Iris (YFI) (*Iris pseudacorus*) is a non-native, invasive plant that is causing substantial changes to the ecology of wetland and riparian areas. Due to the limited options for invasive plant management in these areas, we explored a non-chemical approach. During a previous study on YFI, we noted the development of footpaths around our study plots. As a result, we decided to conduct both field and greenhouse studies to explore the effects of trampling on YFI and determine if trampling is a potentially

effective tool to reduce YFI abundance. When greenhouse grown YFI plants reached 20-30 cm in height, two groups were “trampled” using a piece of 1.27 cm diameter electrical conduit. Treatments included trampling at the plant crown, trampling 1-2 cm above the plant crown, and a non-“trampled” control. Two months after treatment, we quantified plant survival and growth (height and number of leaves). We also conducted a field study to determine the effects of trampling on shoot density and height of YFI in the riparian area of the Niobrara River, at Agate Fossil Beds National Monument. Because permitting requirements prevented bringing cattle into the national monument in a reasonable timeframe, we implemented a citizen science project. The Harrison High School (Nebraska), Future Farmers of America Chapter, volunteered to help us trample YFI for the study. Sixteen 2x2 m study plots were randomly located in YFI infestations along the Niobrara River. Half of each plot was trampled in June 2015 and the other half was an untreated control. Iris density and height was recorded before treatment (May 2015) and three months after treatment (September 2015). Preliminary results suggest that a one-time trampling treatment significantly reduces both iris density and growth. Analyses are underway and this talk will report results from the field and greenhouse trampling studies.

LESSER PRAIRIE-CHICKEN FORAGING IN NATIVE AND CRP GRASSLANDS OF KANSAS AND COLORADO.

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Survival during brooding and winter periods can be critical for assessing factors influencing lesser prairie-chicken (LEPC, *Tympanuchus pallidicinctus*) population growth rates. Food may be particularly important during these periods. During the brooding period, rapidly growing LEPC chicks have high calorie demands and are restricted to foodstuffs within their immediate surroundings. During cold winters, meeting thermoregulatory demands on available food items of limited nutrient content may be challenging. Therefore, our objective was to determine the primary animal and plant components of LEPC diets among native prairie, cropland, and Conservation Reserve Program (CRP) fields in Kansas and Colorado during brooding and winter using a DNA barcoding approach. LEPC fecal samples (n = 314) were collected during the summer of 2014 and winter of 2014–2015, labeled, frozen, and DNA was extracted. Sequences were classified to Order for invertebrates and Genus for plants based on the best matching barcode. To determine species consumed, sequences of the cytochrome oxidase I (COI) gene was used for animals and the trnl plastid region was used for plants. Among 80 readable fecal samples for invertebrates, 35% of the sequences were from Lepidoptera, 26% from Orthoptera, 14% from Araneae, and 13% from Hemiptera. Plant sequences from 137 fecal samples were comprised of *Ambrosia* spp. (28%) followed by species in genera similar to *Symphyotrichum* (10%), *Medicago* (6%), and *Triticum* (5%). The predominant use of Lepidopteran prey contrasts with past research for which Orthopterans were the main dietary component.

&LDQUO;CAN&RSQUO;T SEE THE PRAIRIE FOR THE CHICKEN&RDQUO;- RETOOLING CONSERVATION FOR THREAT REDUCTION OF IMPERILED SPECIES.

Christian A. Hagen*

Oregon State University, BEND, OR

The lesser prairie-chicken (*Tympanuchus pallidicinctus*) is a species of conservation priority because of long-term population declines and changes in native prairie habitat; primarily conversion of native prairie to other uses. With large acreages of Conservation Reserve Program (CRP) expiring and new limitations on total acres to be enrolled, in 2010, The Natural Resource Conservation Service (NRCS) initiated its Lesser Prairie-Chicken Initiative (LPCI) to retain these CRP fields as grassland and transform them into working lands. The LPCI was expanded to capitalize on 27 NRCS practices that can assist in addressing other threats to the species, which include woody plant encroachment, improper livestock grazing, and fence collision risk. Since listing of the lesser prairie-chicken as "threatened" under the Endangered Species Act in 2014, enrollment in voluntary conservation has declined across its distribution. The LPCI is in the process of "retooling" to reengage landowners in voluntary conservation actions. This presentation explores scientific and social strategies to reinvigorate efforts to conserve the bird, the prairies and ranching lifestyles in the southern Great Plains.

APPROACHES TO MANAGE CATTLE USE OF RIPARIAN AREAS: AN EXAMPLE FROM SOUTHEASTERN IDAHO.

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Livestock use of riparian areas has long been a concern of range managers and livestock producers. Low stress livestock herding (i.e. stockmanship) and supplemental feeding of low moisture blocks (LMB) have been effective tools to manipulate cattle movements. This research was based on the assumption that without active management cattle would spend a great deal of time near riparian areas. Our objective was to evaluate the efficacy of using low stress livestock herding combined with strategic placement of (LMB) supplements to reduce the time cattle spend in riparian areas. We divided the grazing season into early and late summer periods. In each period we applied two treatments: 1) conventional management (CM) - traditional herding once a week and no LMB; 2) Stockmanship and strategic supplementation (SSS) - low stress herding 5 days per week plus strategic LMB placement on uplands. Treatments were applied during 2013 and 2014. During the late period of 2013, when weather conditions were near normal, SSS cattle spent more time (P = .01) at higher elevations away from the stream than early season SSS cattle. In contrast to our initial assumptions no differences in cattle movements between TS and SSS treatments were detected during the second grazing season. Less than 7 % of GPS locations were within 150 m. of the stream for in both treatments. In August precipitation was 370 % of normal and the average daily high temperature was 12% below normal. Apparently the wet and cool conditions facilitated cattle use of upland areas. The presence of wolves also may played some role in the limited use of riparian areas by cattle. Although SSS appeared effective during drier weather conditions, use of such labor intensive and potentially expensive management to reduce cattle use of riparian areas may not always be necessary.

KILLING TREES AND MAINTAINING PRAIRIE FOR LESSER PRAIRIE-CHICKENS THROUGH PATCH-BURN GRAZING.

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The lesser prairie-chicken is a species of prairie-grouse that has experienced a dramatic population decline during the past two decades. Several reasons have been cited for these recent declines including invasive tree and shrub encroachment on native prairie as well as the loss of natural ecological drivers, including fire. We evaluated the response of lesser prairie-chicken space use and nest site selection in relation to tree encroachment. We found that lesser prairie-chickens utilized areas with less than 2 trees per hectare more frequently than areas with greater than 2 trees per hectare. Additionally we did not detect any lesser prairie-chicken nests in areas with greater than 2 trees per hectare. One way of controlling trees is through the use of prescribed fire. Little is known about how prescribed fire impacts lesser prairie-chicken habitat and space use. We measured vegetation characteristics across a landscape modified by fire and grazing in a patch-burn grazing system to assess the impacts of prescribed fire on lesser prairie-chicken habitat. We also measured vegetation characteristics at lesser prairie-chicken nest sites and paired random locations. We found that patches greater-than-2-years post-fire had 2x taller vegetation than year-of-fire patches. In addition, year-of-fire patches had the greatest bare ground and litter whereas patches greater-than-2-years post-fire had the most grass cover and the least bare ground. Lesser prairie-chicken nesting locations had similar vegetation height and structure to that of patches that were greater-than-2-years post-fire. Nest sites had taller vegetation, greater grass cover, and less bare ground cover than paired random locations. Our findings show that patch-burn grazing helps maintain lesser prairie-chickens nesting habitat and therefore, may be a useful tool for controlling tree encroachment.

EVALUATION OF FACTORS COMMONLY USED TO CALCULATE CATTLE STOCKING RATES ON EXTENSIVE AND MOUNTAINOUS RANGELANDS.

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Published research provides a framework for adjusting stocking rate calculations for uneven grazing distribution. Global positioning system (GPS) tracking was used to evaluate if commonly used stocking rate adjustments reflect actual cattle movement patterns in a variety of landscapes. A total of 159 cows were tracked for 1 to 4 months at 7 ranches in New Mexico, Arizona, and Montana. At a ranch with rolling terrain and numerous water locations cows spent 92% of their time within 1609 m from water. At two other ranches with only one water source, cows spent 41 to 57% of their time between 1609 and 3218 m from water and 1 to 11% of their time greater than 3218 m from water. At ranches containing a significant amount of gentle terrain, cattle spent less than 20% of their time on slopes over 10%. However, at 2 mountainous ranches (average slope > 20%), cows spent 33% and 74% of their time on moderate slopes (11 to 30%) and 10% and 14% of their time on slopes greater than 30%. Although vertical distance to water clearly affects grazing distribution, only one study reported its impact on forage utilization and suggested that cattle did not use areas over 80 m vertically from water. Cows at two ranches spent 17% and 28% of their time over 80 m vertically from water. Managers should be

cautious when using published grazing distribution adjustment in stocking rate calculations. Cattle that are adapted to local conditions may readily use moderate slopes and areas that are far (horizontally and vertically) from water, which would negate the need to reduce stocking rates in areas over 1609 m from water and slopes over 10%. Stocking rate adjustments based on actual field measures of distribution rather than published values are likely more accurate.

MULTIPLE USES OF MEXICAN RANGELANDS AS A TOOL FOR SUSTAINABLE RANCHING.

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Multiple uses are viewed as the most appropriate way of exploitation of the vegetation cover of rangelands. It implies harmony among users for more than one purpose, for the way in which has led to maintain productivity, goods and services of the ecosystems, as well as to contribute to the sustainability of human communities. Now with the new Mexican laws that gives priority to energy and mining production above others uses of the rangelands, such as forage production for the maintenance of livestock and wildlife, new issues and concerns arise about validity of the concepts of multiple use and sustainable use. These changes in paradigm foresee degradation of ecosystem services which contributes to the livelihoods and preservation of biological, social, economic, and patrimonial values of the stakeholders. Proposals such as the ones which will be presented at this Symposium: Current situation and challenges of cattle/wildlife operations. Habitat and wildlife recovery efforts. Habitat conservation. Endangered species recovery. Alternative use of wildlife in grasslands. Management of exotic grasses. Game species associated, are just examples of other economic activities which can be undertaken in the rangelands of Northern Mexico.

MODELLING THE IMPACT OF CLIMATE CHANGE ON NATIVE SHRUB COMMUNITY DYNAMICS IN THE SOUTHERN PART OF THE MEDITERRANEAN BASIN.

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Global climate change has been shown to impact rangeland environments by reducing biodiversity, degrading vegetation structure and hindering plant community resilience. These effects may be accentuated with poorly managed grazing regimes. In the southern Mediterranean region, native shrub species such as *Salsola vermiculata* L. and *Atriplex leucoclada* (Boiss) provides an important forage for the production of meat and wool that supports local agro-pastoralists. In contrast, H*aloxylon salicornicum* (Moq.) is an invasive species that is a non-palatable shrub that competes with desirable native species. The purpose of this study is to assess the influence of climate change on the establishment and growth of these shrub species. Climate envelopes were generated to predict potential effects of climate change on vegetation response. Environmental variables included in the analysis were eight climate, three soil property, one altitude, and one grazing pressure layers. Results indicate that preferred shrub species are declining due to the combined effects of climate change and

grazing pressure. While the undesirable species have an advantage due to reduced competition for water and nutrients. These results suggest that without improved management, these sensitive communities could experience elevated degradation. In fact, an adaptation strategy is needed to increase the resilience of the most vulnerable species based on grazing management, the selection of more drought tolerant taxa and the establishment of other mitigation measures, such as water harvesting techniques.

THE VALUE OF INTEGRATING FARMER PERCEPTIONS OF GRAZING AND LANDSCAPE WITH BIOPHYSICAL EVIDENCE.

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Adaptive grazing approaches such as holistic management (HM) involve decision-making based on explicit goal-setting and careful monitoring, often characterized by native pastures and high-intensity but short-duration rotational grazing. Science is divided on the utility of such practices: experimental scientists see no benefits from the constituent practices in controlled experiments, while management-oriented agricultural scientists report benefits at the farm scale. To date, producer experience and perceptions have been neglected or dismissed, but also under-tested in appropriate ways. Social sciences have an important role to play in understanding and resolving the schism around adaptive grazing strategies, including the potential utility of such management for climate adaptation and the validity of producer perceptions as evidence in doing so. Moreover, however, it is valuable yet still uncommon to design research to produce paired data across research paradigms. This presentation will include: (1) a brief primer on social research principles and how evidence acquired using such methods should be assessed and used; (2) a case study of Australian ranchers, to explore the value of understanding the producer perspective on landscape and grazing practices, particularly in the face of climate change; and (3) suggest ways that shared case studies across biophysical and social sciences can improve overall understanding of farm-scale management and its outcomes. The Australian case study involved 25 ranchers, stratified across grazing practices (stocking intensity and rotation regime), was undertaken using photo-based landscape elicitation methods but also field ecology and farm-gate economics, in the final years of a decade-long drought, locally called the 'big dry'. Integrative insights contributed to policy engagement in Australia, and the recent incentivization of water and fencing infrastructure associated with adaptive grazing practices, but also inspired further research questions now underway, adding integrative case studies in Canada and the Falkland Islands.

LONG-TERM EVALUATION OF LESSER PRAIRIE-CHICKEN NEST ECOLOGY IN RESPONSE TO GRASSLAND RESTORATION.

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Much of the current lesser prairie-chicken range in New Mexico and Texas is restricted to sand shinnery oak prairies, on which cattle grazing is the main socioeconomic driver for private landowners. Cattle producers within shinnery oak-prairies often focus land management on shrub eradication using tebuthiuron to promote grass production for forage; however, herbicide application alone, and in combination with grazing, may affect nest site selection and survival of lesser prairie-chickens through the reduction of shinnery oak and native grasses. We used a controlled, paired completely randomized design study to assess the influence of grazing and tebuthiuron application on nest site selection and nest survival in 4 treatments from 2001–2010 in New Mexico. Grazing treatment was a low-intensity, short-duration system in which plots were grazed once during the dormant season and once during the growing season. Stocking rate was calculated each season based on measured forage production and applied to remove not greater than 25% of available herbaceous material. We compared nest site selection among treatments using 1-way χ2 tests and nest survival among treatments using *a priori candidate* nest survival models in Program MARK. We identified important habitat predictors of nest site selection and nest survival using logistic regression and *a priori candidate* nest survival models in Program MARK, respectively. Hens typically used treatments as expected and no trends in selection were detected. Nest survival did not differ among treatments. Nests had less bare ground and greater angles of obstruction compared to random sites and survival estimates were similar among habitat covariates. Results suggest a tebuthiuron application rate of 0.60 kg/ha, short-duration low-intensity grazing, and a combination of these restoration techniques were not detrimental to lesser prairie-chicken nesting ecology. Intensified management that increases bare ground or reduces overhead cover may negatively impact lesser prairie-chicken nesting habitat and nest survival.

HIEARCHICAL MODELING OF LESSER PRAIRIE-CHICKEN ABUNDANCE, SURVIVAL, AND RECRUITMENT IN RESPONSE TO GRAZING AND WEATHER.

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We examined impacts of grazing and weather on lesser prairie-chicken abundance, survival, and recruitment while simultaneously accounting for imperfect detection from 2004-2014 in shinnery oak prairies of New Mexico. We used maximum number of males per lek as the response variable and used number of graze days/ha per pasture, rainfall, annual maximum daily temperature (AMT), and number of days with maximum temperature > 90th percentile (MAX90) as site-level covariates. We modeled effects of weather parameters on survival and recruitment from the same year of sampling and up to three years before to account for potential time lags in population response. Grazing did not affect abundance. Weather parameters did not directly influence survival. Effects of AMT varied by time lag, but typically negatively affected recruitment and appeared to have a greater impact than rainfall or MAX90. Results suggest that abudance is not affected by grazing up to 0.023 days/ha per year. Weather appears to affect reproduction efforts more greatly than adult male survival during lekking.

ALTERNATIVE USE OF WILDLIFE IN GRASSLANDS OF CENTRAL MEXICO.

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People needs in rural communities of central Mexico, coupled with climate change that is usually accompanied by excessive dry or wet conditions, and the current wildlife management system in Mexico, has led to alternative uses of wildlife that inhabit the grasslands of this region. In Mexico, the use and management of wildlife is based on the System of Management Units for the Conservation of Wildlife (UMA). However this system, in most cases, leaves ejidal communities (communal land property) in disadvantage, beside soil erosion and overgrazed pastures that occur in its properties. In these communities there are only small game species as collared peccary (*Pecari tajacu*), rabbit (*Silvilagus floridanus*), black-tailed jackrabbit (*Lepus californicus*), coyotes (*Canis latrans*), white-winged dove (*Zenaida asiatica*), mourning dove (*Zenaida macroura*) and an inability to pay for technical services required by the UMA system. In this situation, the capture and sale of white-throated woodrat (*Neotoma albigula leucodon* Merriam), and the collection of edible insects for human consumption such as escamoles (reproductive caste of the escamolera ant-*Lyometopum apiculatum*), red (*Comadia redtenbacheri*) and white worms (*Acentrocneme hesperiari* W.) are important as source of food and income for rural dwellers. The market value of each white-throated woodrat is $ 2 US dollars, but the price of edible insects in rural communities fluctuates between 16 and 20 US dollars/kg; although they reach a price of 33 Dollars at the restaurant. Capture of white-throated woodrat and insect collection are complementary activities to the agricultural and farming activities that community people practice during the year. This talk will address the harvest of these species in central Mexico, its importance and management, with problems they face and the challenges toward their sustainable management in the states of Zacatecas and San Luis Potosi, Mexico.

JUST ADD WATER: SEEDLING ESTABLISHMENT FACILITATION USING BIODEGRADABLE WATERING VESSELS.

Jessee L. Page*, Amy C. Ganguli, Brian J. Schutte

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Drought, dams, and invasive species have drastically altered watercourses like the Rio Grande River. Areas that traditionally supported riparian vegetation contend with altered site potential stemming from modified hydrology and soil properties. The largest hydropower dam on the Rio Grande River is Elephant Butte, which primarily controls the water released in south-central New Mexico, the quantity varies year-to-year resulting in subsequent water table lowering. Restoration projects aimed at reestablishing riparian vegetation contend with difficult conditions. One solution is to supply water via irrigation or methods that target water delivery to seedling roots. Our objective was to evaluate biodegradable water delivery system developed by the Land Life Company. We conducted a trial in May 2014, which represented the harshest conditions (i.e., hot and dry) this monsoonal system experiences.

We planted one-year old Rio Grande Cottonwood (*Populus deltoides* subsp. *wislizeni*) seedlings in three types of water delivery vessels and had a control without a vessel. Survival was universally low (2.4%) due to water loss and harsh conditions. We conducted an additional planting in the fall, which is a recommended time for seedling transplants in this system. In addition to cottonwood we assessed a drought tolerant species, desert willow (*Chilopsis linearis*). One vessel design, with a water capacity of 22 liters, was used with an addition of peat-moss/sand mix. The treatments included, vessels with and without peat-moss and a no vessel control. Survival for cottonwood was low due to seedling removal and herbivory by mammals. Desert willow survival was higher with peat-moss treatments (42%) compared to the controls (16%), however there was no difference between the peat-moss treatments, suggesting no advantage of the water delivery vessels. Our preliminary data illustrates challenges associated with establishing riparian vegetation in the southwest and suggests that it may not be enough to "just add water".

REAL-WORLD EXAMPLES AND RESULTS OF EAGLE FORD SHALE RESTORATION EFFORTS USING NATIVE PLANTS.

Wallace Nichols*

Native Habitat Restoration, Austin, TX

Restoration of native plants is often desired by landowners following Eagle Ford Shale exploration activities. Native Habitat Restoration is a private restoration services company that has done extensive reseeding work for landowners and the oil and gas industry in South Texas using native seeds developed by the South Texas Natives Program. Important components of successful oil and gas restorations will be discussed, including: the role of early successional native plants in establishing rapid vegetation cover; the importance of proper seed mix selection for specific soils and restoration sites; concerns and limitations regarding timing of seeding; and the implications of site preparation prior to seeding. Photographs and case studies of successful drill and hydroseeding restoration projects on pipeline rights of ways, pad site reductions, and frack tanks will be presented. Suggestions and practical considerations for insuring the success of oil and gas-related native plant reseeding projects in both the Eagle Ford Shale and other regions will be communicated.

INFLUENCE OF NEST FATE ON NEST CONCEALMENT AND PLACEMENT OF SUBSEQUENT NESTING ATTEMPTS OF BOBWHITES.

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Caesar Kleberg Wildlife Research Institute, Kingsville, TX

The northern bobwhite (*Colinus virginianus*) is an important game bird in Texas. Much is known about bobwhite nesting ecology; however, relatively little is understood regarding how nest predators influence bobwhite nest selection and re-nesting behavior. The objective of our research is to compare how the fate of an initial nest influences the re-nesting behavior of bobwhites (i.e., concealment, placement, and success of subsequent nests). Our study was conducted on 5 spatially independent

study sites across South Texas, in Brooks (2000–2008) and LaSalle (2009-2011) and Goliad, Real, and Zavala counties in 2014. Through the use of radio-telemetry, we collected information on nest fate, nest substrate, and microclimate. In addition, we sampled concealment and herbaceous cover at nest sites. Data is currently being analyzed and the study will conclude in 2016.

ALDO LEOPOLD&RSQUO;S COW: CAN CATTLE BE USED AS A DEER HABITAT MANAGEMENT TOOL?

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Aldo Leopold suggested in his book *Game Management* that cattle (*Bos spp.*) could be used as a habitat management tool. Our objective was to determine if cattle grazing increased forbs preferred by white-tailed deer (*Odocoileus virginianus*) in south Texas. Every autumn for 3 yr, we collected standing crop of 1) grasses, 2) nonpreferred deer forbs, and 3) preferred deer forbs at 300 paired ungrazed and grazed sampling plots located on East Foundation ranches, spanning from the Gulf Coast to western south Texas. Prior to the formation of the East Foundation, the ranches had a long history of overgrazing; cattle utilization ranged from 45–95% during this study. We report the effect on the median standing crop of forbs (grazed compared to paired ungrazed) for every 1% increase in cattle grazing utilization. During 2012 there was ~ 1.4% increase ($P = 0.039$) in nonpreferred forbs with increasing utilization; in 2013 nonpreferred forbs decreased ($P = 0.079$) ~ 1.2% with increasing utilization. There was no relationship ($P = 0.767$) between grazing utilization and nonpreferred forbs during 2014. There was no relationship ($P = 0.430$) between preferred forbs and grazing utilization during 2012, but there was ~ 1.4% and 2.0% increase ($P \leq 0.030$) in preferred forbs during 2013 and 2014, respectively. Even though the effect of cattle grazing on preferred deer forbs was not biologically significant, < 3.5 kg · ha-1, no negative impacts of cattle grazing were detected. Cattle grazing has little effect on forbs in south Texas whether they are preferred by deer or not; its use as a habitat manipulation tool to increase food for deer is not substantiated for areas with a long history of overgrazing.

INVESTIGATING DIET OVERLAP AMONG NILGAI, DEER, AND CATTLE USING STABLE ISOTOPES.

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Stable isotope analyses can be applied to investigate niche partitioning among species. This information can reveal potential for interspecific competition for forage resources. Our objective was to determine if nilgai (*Boselaphus tragocamelus*), white-tailed deer (*Odocoileus virginianus*), and cattle (*Bos spp.*) diets overlap during peak growing seasons and a non-growing season in south Texas. During autumn, spring, and winter 2012-2014, we randomly collected 20 fresh fecal samples for each species across six 2 500 ha study sites on East Foundation ranches in south Texas spanning from the Gulf Coast to western south

Texas. We analyzed carbon (δ13C) and nitrogen (δ15N) isotope signatures of fecal samples to determine the isotope niche signature for each species in relation to other species. Preliminary results suggest (1) nilgai diets overlap with deer; (2) nilgai and cattle diets overlap very little; and (3) cattle and deer diets overlap strongly only when little grass is available. Past research on nilgai, based on microhistological analysis, suggested nilgai diets are 60–70% grasses. However, during this study, even in favorable years when grasses were available, nilgai diets were < 40% grasses. Therefore, during peak growing seasons in south Texas, when forage availability is at its highest, nilgai consume a larger percent of forbs and browse, less grass than previously suggested, and have a higher probability of competing with deer during times of low forage productivity.

HABITAT AND MOVEMENT PROCESSES OF PLAINS BISON IN A NUTRITIONALLY HETEROGENEOUS LANDSCAPE.

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Maintaining pyric herbivory, the fire-grazer interaction, in grasslands requires a mechanistic understanding of the effects of landscape heterogeneity on grazer movements and habitat selection. Using an analytic framework for simultaneously quantifying the effects of habitat preference and intrinsic movement on space use, we examined how female bison assess the forage quantity-quality tradeoff at the landscape-scale. We evaluated the association of dynamic, biotic forage resources and static, abiotic landscape features with movement and habitat selection in an experimental mesic grassland, Konza Prairie Biological Station. At Konza Prairie, forage resources vary in response to prescribed burning, grazing by a native grazer, and variable weather. We integrated 6 years of growing season locations of GPS-collared plains bison with their forage landscape derived from vegetation surveys (biomass and foliar protein content) to understand what drives bison movement. Preference for high foliar crude protein content and low stature forage structure was consistent across years, although substantial variation in the magnitude of selection of these resources occurred among years. In years of below-average plant productivity, the strength of selection for high foliar crude protein content was greater than in years of normal to above average plant productivity. Avoidance of areas with high herbaceous biomass content was strongest during years of low plant production. Climatic interactions between plant quality and quantity seemingly shaped bison distribution as they sought to maximize nutrient gains by selecting areas containing short or immature plants of high nutrient (protein) value. Our results provide experimental evidence for documenting a key behavioral mechanism that drives fine-scale movement of a large grazer in response to fire- and local-climate-induced changes in forage attributes.

PROVISIONAL IMPACTS OF FIRE-MEDIATED HABITAT ALTERATIONS ON A REINTRODUCED BIGHORN SHEEP POPULATION.

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Translocation is considered a primary tool to reestablish or bolster waning populations of many wildlife species, and is often accompanied by habitat alterations in an effort to improve and expand suitable habitats. We used GPS locations collected from 38 bighorn sheep (*Ovis canadensis*) translocated to the Seminoe Mountains, Wyoming, in 2009 and 2010, as well as from 24 bighorns captured in our study area in 2011 to investigate provisional impacts of prescribed and wildfire-mediated habitat alterations that impacted ~24% of the study area in 2011 and 2012. We conducted analyses that quantified home range distributional changes, resource selection, and survival of bighorn sheep from 2009 to 2013. Bighorns expanded home ranges and increased proportional use of fire-treated areas; however, regression model coefficients indicated no overall selection for fire-treated areas. Bighorn survival decreased by over 30% after fires in 2012 that were accompanied by severe drought conditions, suggesting prescribed fires conducted under favorable conditions (2011) induced potentially positive bighorn responses including high survival and increased use of treated areas, whereas fires that occurred during drought conditions that were generally more severe and widespread (2012) coincided with increased bighorn mortality rates in spring 2013. Furthermore, bighorn mortality associated with poor body condition had higher home range overlap with burned areas ($t7 = -2.44$, $P = 0.045$). Our study suggests that large-scale fires coupled with unfavorable weather conditions rendered bighorns unable to access adequate forage to meet nutritional requirements because they were unwilling to forego site fidelity. Because impacts of fires on bighorn populations are highly dependent on ensuing vegetative recovery, consideration should be given to the timing, extent, and spatial coverage of prescribed fires. Therefore, we recommend conducting prescribed fires before bighorn reintroductions, or conducting prescribed fires on a relatively small scale and on a rotational basis to avoid impeding foraging options.

AGENT BASED MODELING OF GRAZING CATTLE IN BMP SELECTION TO PROTECT DRINKING WATER SOURCES.

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Cattle grazing on rangeland in community drinking water catchments is recognized as a potential source of pathogens to drinking water surface sources. In the province of British Columbia, Canada (BC), Cryptosporidiosis outbreak incidents in the communities of Cranbrook and Kelowna in 1996 have generated public concern about the presence of grazing cattle in community watersheds. An audit of forest practices in 2010 subsequently led to the development of a pilot project in four community watersheds to develop Best Management Practices (BMPs) to mitigate the potential for this hazard. Subsequently there is pressure to expand the use of these BMPs to other watersheds. Effective and efficient deployment of these BMPs dictates that decision makers have an understanding of 1) the expected behaviour of cattle in a watershed including their routes of migration, and where, when, and how long they might access resources (feed, water, shade, and shelter) in the watershed, and 2) the presence of *Cryptosporidium parvum (C.parvum)* in their faeces and its persistence as a viable pathogen. With increased understanding of cattle movement from the use of GPS collar recorders, modern Agent Based Modeling is one possible approach to quantifying and gaining insight to efficacy and efficiency of BMPS to mitigate *C.parvum* contamination as a potential drinking water source hazard

in other watersheds. This paper will explore the development, implementation and validation of an Agent Based Model (ABM) as a tool to support the selection and optimization of BMPs to mitigate risks to drinking water sources from cattle. It will also explore the underlying data requirements for this model, and the assumptions with respect to *C.parvum* persistence in BC's community watersheds as derived from both field and laboratory environment research, and the integration of the ABM results in Quantitative Microbial Risk Analysis (QMRA).

PHYSIOLOGICAL TRAITS OF GRASSES AND SHRUBS INFLUENCE THE CONVERSION OF C4 GRASSLAND TO SHRUBLAND.

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North American mesic grasslands occupy a unique ecosystem space where frequent disturbance and climate variability intersect. Mesic tallgrass prairie is typically characterized by few highly productive C4 grass species, but includes diverse assemblages of other forbs, grasses, sedges, and woody plants. Species persistence in this ecosystem requires tradeoffs that balance competitive efficiency for resources, and an ability to tolerate (or avoid) frequent disturbance. Over the past 30 years, woody shrubs have increased dramatically in grasslands, shifting the ecosystem state from grassland to shrubland across landscapes. These alternative stable states have resulted from reductions in fire frequency, habitat fragmentation, and climate change. What unique attributes of woody shrubs have shifted the balance of power from C4 grasses to shrubs in grasslands? In this presentation, I will discuss the significance of physiological and morphological characteristics among C4 grasses and C3 woody shrubs within the context of frequent disturbance and drought. The physiological traits employed by these dominant growth forms influence water stress, uptake, and overall water flux. Ultimately, distinct traits and ecohydrological strategies among grasses and shrubs are key regulators of the rates and trajectories of woody encroachment in the tallgrass prairie.

HERDING TRANSITIONS AFTER PRIVATIZATION AND SETTLEMENT IN WESTERN XINJIANG, CHINA.

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The Xinjiang Uyghur Autonomous Region in China's far northwest includes extensive rangelands used by ethnic Kazakhs. The breakup of the commune system and privatization of leasehold title in the 1980's has only recently been followed by government-led economic development and settlement schemes. Land privatization and settlement of herders has been implicated in grassland degradation and livelihood conversion in other areas of China, but early outcomes among Kazakh herders have been little studied. This talk will present the findings of early-stage interview-based research conducted with ethnic Kazakh pastoralists in the Ili Valley, close to the Kazakhstan border. We conducted semi-structured interviews with 65 households in three designated pastoral villages in Nileke County, Ili Prefecture, in order to learn how development projects have affected Kazakh pastoral communities. In two villages, households have received private leasehold rights to their three seasonal pastures, while the third

village allotted its three seasonal pastures to groups of seven-to-ten households for group management. Despite a history of collective management, conflicts over pastures in all three villages were common and interviewees complained of lack of resolution mechanisms, preferring government intervention to other forms. Livestock constituted the dominant income source among interviewees, even among those households without pastures. Partly due to snowfall and partly to recent settlement schemes, purchased fodder is crucial for getting most livestock through the winter and fodder is the single largest annual expense for most households. Nearly all interviewees agreed that pastures were significantly degraded and that there was little future in raising livestock. The best future for children was seen as post-secondary education and non-livestock employment, mostly in cities.

COLLABORATIVE ADAPTIVE GRAZING MANAGEMENT FOR MULTIPLE ECOSYSTEM SERVICES: CAN IT CLOSE THE LOOP?

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The shortgrass steppe of Eastern Colorado is a complex social-ecological system where management objectives for livestock production, wildlife, and vegetation heterogeneity converge. The Adaptive Grazing Management (AGM) experiment is a 10-year project initiated in 2012 and aimed at fostering partnerships and data-driven rangeland management through a participatory multi-stakeholder approach. This study evaluates collaborative adaptive management (CAM) as a potential tool within the AGM experiment to 1) co-construct and link multiple scales of knowledge and 2) plan and implement adaptive grazing management for the provision of multiple ecosystem services. We document and evaluate the first two years of the AGM project as ranchers, representatives from land management agencies and environmental organizations, and researchers work together in a mock public lands management scenario. We qualitatively evaluate transcripts of Stakeholder Group meetings. At these meetings group members chose and prioritized desired ecosystem services, determined criteria for livestock movement among pastures, and selected and evaluated monitoring approaches. Since 2012 the Stakeholder Group has identified consensus goals and objectives. They have developed and implemented an adaptive grazing management plan for a 10 pasture 200-steer operation that includes a pulse grazing strategy, measurable triggers for moving livestock between/among pastures, and decision criteria for making between-year adjustments to grazing sequences. The group has also implemented opportunistic vegetation management such as patch burns following a high-production year in 2014. Our findings suggest that CAM can 1) confer connections between experiential and experimental knowledge and 2) close the adaptive management loop on rangelands by connecting monitoring results to adaptive decision-making. CAM approaches hold promise in enhancing the adaptive capacity of decision-making in the face of social and environmental change.

RANGE-WIDE CHANGES IN HUNTER MANAGEMENT TO REDUCE HARVEST PRESSURE ON GREATER SAGE-GROUSE.

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Hunter harvest has been identified as a potential factor contributing to population decline of greater sage-grouse (*Centrocercus urophasianus*; hereafter "sage-grouse"). However, regulated sage-grouse hunting has consistently been administered by wildlife agencies throughout western North America. Many peripheral populations have been closed to hunting beginning with closures in the 1950s. To reduce the potential for additive effects, harvest season regulations throughout the range of sage-grouse have become more conservative over the past two decades in efforts to lower hunter participation and concomitant numbers of harvested sage-grouse. We compiled data on harvest season regulations, and estimated numbers of birds harvested and hunters afield from 11 western U.S. states and 2 Canadian provinces from 1995 to 2013. We summarized change in harvest effort as a function of reductions in legal area to hunt, bag and possession limits, season length, season start date, and hunt type (permit only or general). We compared reductions in open (legal) harvest boundaries and area-weighted average harvest regulations relative to administrative boundaries and sage-grouse populations. These comparisons allowed us to assess how change in harvest regulations elicited realized harvest pressure reduction. From 1995 to 2013, there was a 25.4% reduction in administrative harvest boundaries compared to a 12.2% reduction in area open to harvest within 8 km from active sage-grouse leks. Corresponding response in area-weighted possession limits and season length decreased 73.0% and 52.3%, respectively, from 1995 to 2013. In conclusion, reduction in harvest regulations implemented in the mid-to-late 1990's were primarily associated with restricting harvest to areas where sage-grouse occurred and eliminating harvest of populations exhibiting severe decline. Since 2000, harvest regulations have focused on reducing the potential for additive harvest effects throughout the range of sage-grouse.

EXPLORING WYOMING&RSQUO;S RANGELANDS AND ITS PEOPLE.

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Rangeland stewardship has a different meaning to different people. To some, it's a duty, to others, a necessity, and to others still, it's a livelihood. The University of Wyoming and University of Arizona came together to develop the Discovering Our Nation's Rangelands project as a pilot project. The overall goal of the project is to develop different Extension educational tools and content to enhance existing websites and to develop templates by which other state Extension Services can adopt and adapt our models. There are various objectives to obtain this goal and with the help of two interns, the University of Wyoming was able to begin accomplishing two of the main objectives 1) to develop short, theme-based videos to document local knowledge about rangeland management and 2) to develop short viewpoint videos on topics of interest. Local knowledge and viewpoint content is collected from both ranchers and agency representatives to gain a full spectrum of ideas and experiences. Individuals are

filmed and then content is edited and compiled into five to eight minute videos which will be posted on various websites and other media outlets (i.e. podcasts). Local knowledge videos are designed to capture what a rancher or land manager has learned about managing a piece of rangeland over their career – the art part of rangeland management.

INDUCING RAPID SEED GERMINATION OF NATIVE COOL SEASON GRASSES WITH SOLID MATRIX PRIMING AND SEED EXTRUSION TECHNOLOGY.

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There is a need to develop cost-effective techniques for reestablishing native vegetation from seed to reclaim degraded ecosystems. We developed a novel approach for accelerating seed germination and improving fitness of young seedlings by priming seeds in a matrix of various absorbent filler materials and bio-stimulants and then forming the mixture into pods for planting. As part of the development process, we determined optimal water potentials and durations for priming seeds in the matrix and then compared seedling emergence from primed seed pods, non-primed seed pods, and non-treated seed. Emergence trials were conducted on two different soils collected from the West Side region of the Kaibab Plateau, USA. *Poa fendleriana* and *Pseudoroegneria spicata* were used as test species. Seeds were primed from -0.5 to -2.5 MPa for up to 14 d. Priming under dryer conditions (-1.5 to -2.5 MPa) for durations that approached germination tended to produce faster germinating seeds. Emergence trials showed that days to 50 % emergence for primed seed pods was between 66.2-82.4 % faster (5.2-14.5 d less) than non-treated seed. Final density of primed-seed pods for *P. fendleriana* was 3.8-fold higher than non-treated seed of the same species for one of the two soil types tested but no significant difference was found on the other soil type. Final density of *P. spicata* primed seed pods were 2.9-3.8-fold higher than non-treated seed of the same species. Overall primed seed pods shows promise for enhancing seed germination and seedling emergence, which could aid in native plant establishment.

NILGAI IN SOUTH TEXAS: NUISANCE OR ASSET?

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Nilgai antelopes (*Boselaphus tragocamelus*) were introduced to the United States from India. In 1929 and 1930, 12 nilgais were introduced to the Norias Division of the King Ranch in South Texas. The population increased to more than 200 by mid-1950, and to 4 500 and 15 000 animals by 1983 and 2004, respectively. Currently, we estimate a population of over 38 000 and individual animals and herds of up to 11 cows have been observed around Kingsville, TX., far north from the initial release site. Nilgais can be viewed as a valuable species for hunting and meat, or as an invasive species that compete for food and space with native wildlife species and it may disperse diseases. In ranches with high cattle stocking rates and low forage availability, nilgai and white tailed deer diets overlapped; under those

conditions they were competing for food. When grass availability is high nilgai may also compete with cattle too since they are intermediate feeders. The value of a nilgai hunt may range from $1 500 to $2 000 for a bull and $500 for a cow and the price of nilgai meat may go from $11 per lb for hamburger patties to $34 per lb for backstrap steakes. Based on this, ranchers may consider the nilgais an asset, even when they are well known to damage fences. Recently, cattle fever ticks (*Rhipicephalus microplus* and *R. annulatus*) were found in nilgais in the Mexico border. This is important because nilgais may move ticks long distances. Nilgai male home ranges ranged from 1 135 to 29 827 ha, and for females from 1 117 to 22 662 ha, therefore, potential for spreading ticks and risk for the cattle industry may be high, however, nilgai hunting is a viable recreational activity and brings additional income to ranches.

VGS AS A TOOL FOR CONSERVATION DECISION-MAKING: NRCS PERSPECTIVE.

Loretta Metz*

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The Conservation Effects Assessment Project (CEAP) uses science to inform policy decisions, enrich conservation planning and implementation, and improve management decisions. A core requirement of CEAP is the use, analysis and interpretation of "big data". Inventory and monitoring data at multiple scales (plot, field, watershed, etc) are necessary to conduct the appropriate assessment of resource conditions on private lands. The National Resources Inventory (NRI) provides a standardized method of inventory data protocols, collection, storage and retrieval. But for data collected outside of the NRI framework, a database is needed that allows users to tailor their data collection and management in an efficient, site-specific, yet standardized manner. Aside from the obvious advantages to field staff, ranchers and researchers, database standardization is necessary for CEAP to utilize multiple data sources. CEAP-Grazing Lands has teamed up with the University of Arizona to adopt their open-sourced Vegetation GIS Data System (VGS) software as the foundational database for grazing land projects. This talk will illustrate the efficiency and benefits of utilizing VGS for CEAP big data needs.

FLAMMABILITY THRESHOLDS OF EASTERN REDCEDAR AS A POTENTIAL INDICATOR FOR HEIGHTENED WILDFIRE DANGER.

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Trees planted as a part of horticultural and conservation practices might not have posed a threat to wildfire under historic climate analogues, but with increased frequency and severity of drought events projected to occur by the end of the century, the traits of some species will cause them to contribute to heightened wildfire danger in coming decades. Foliar fuel moisture content (FMC) plays a key role in determining foliar flammability, with lower FMC associated with higher wildfire risk. Quantifying tipping points in flammability is crucial if we are to have a better understanding of when wildfire risks are

highest. Our study quantified thresholds in flammability of Eastern redcedar (*J. virginiana*), an invasive native tree commonly planted throughout the Great Plains. Using a MC320LHT thermal imaging camera, we captured three common characteristics of flammability: ignitibility (time to ignition), sustainability (time-spent combusting), and combustibility (velocity/intensity of combustion). Foliar samples were 6 cm in length and were harvested from female Eastern red cedar trees ranging from 3-4 m in height in Seward County, NE. FMC classes ranged from 0% - 180% in 10% intervals. Each FMC class was subjected to flammability tests under a laboratory vent hood with no forced airflow. A Bunsen burner provided the pilot flame and a thermal imaging camera was used to record time of ignition, time-spent combusting, flame height, and temperature of the combusting sample. Our data demonstrate that flammability thresholds exist for J. virginiana and are expressed through measurements of ignitibility and combustibility. At FMC's of approximately 60%, time to ignition rapidly decreases and the intensity of combustion rapidly increases. Based on these findings, the flammability of *J. virginiana* and its associated wildfire risk is much higher during periods of drought and should be considered as part of wildfire danger monitoring protocols in the Great Plains region.

PATCH-BURNING SUPPORTS HETEROGENEITY OF PRAIRIE-CHICKEN HABITAT.

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Decades of fire suppression in the Great Plains have resulted in conversion of grass-dominated prairies into woodlands. This conversion has led to dramatic decreases in the availability of suitable prairie-chicken (*Tympanuchus spp*.) habitat. Recently, land managers and conservationists have attempted to combat this woody encroachment through the use of patch-burning, the patchy application of prescribed fire followed by grazing, which takes advantage of the fire-grazing interaction. The result is increased heterogeneity of vegetation community composition and structure. Our study compares the effects of patch-burning to fire alone on current and historic prairie-chicken habitat. Four vegetation types are represented by four sites across Texas and Oklahoma: tallgrass prairie, shinnery oak, sand-sagebrush, and gulf coastal prairie. All sites are within the historic or current distribution of either Lesser (*T. pallidicinctus*), Greater (*T. cupido cupido*), or Attwater's Prairie-Chickens (*T. cupido attwateri*). Three sites currently practice patch-burning, while the fourth uses prescribed fire alone. Un-grazed areas are available at each site for comparison to patch-burn treatments. At each site, we measured vegetation characteristics important to prairie-chicken habitat. Measurements were taken along transects in patches with different times since fire. Vegetation community composition differed between patches with different times since fire. These results suggest that patch-burning does indeed increase heterogeneity of vegetation structure, providing a suite of habitat types necessary for prairie-chickens throughout the year.

VARIATION IN GRASSLAND FUEL CURING IN SOUTH AFRICA.

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Fire maintains ecological function in many ecosystems worldwide, especially mesic sub-Saharan rangelands. But much rangeland fire research occurs in a wildfire context, is focused on fire effects, or simply assumes grass-dominated fuelbeds are homogeneous. We sampled fuel moisture from several species in two grassland locations in South Africa to determine (1) if grassland fuels cure differently among species and/or across locations, (2) whether differences in curing meaningfully affect fire behaviour, and (3) if fuel moisture is associated with soil moisture. Data were characterised by high variability. Variability among sampling sites and dates highlights the importance of accounting for—rather than averaging out—variation with hierarchical analysis. Variability among locations and species indicate that broad similarities among plant communities do not adequately describe fuelbed dynamics. We observed patterns in the C3 *Festuca costata* that deviated from general patterns in C4 grasses—in grasslands at the edge of environmentally-determined transitions, these differences might have landscape-level implications under global environmental change. The temporal breadth and species-level specificity of our study constitute novel data that identify further research to improve understanding of fuelbed ecology in grassland worldwide beyond the context of extreme fire weather and behaviour. Our data suggest managers in South Africa and abroad should consider heterogeneity within grassland fuelbeds and recognize seasonal changes to ensure objectives are obtainable ahead of burns and to explain spatial variation in response within what might have appeared a homogenous grassland fuelbed.

WILDFIRE, DROUGHT AND CONCERNS OVER DESTABILIZATION OF THE NEBRASKA SANDHILLS.

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The potential for disturbances to shift an ecosystem to an alternative ecological state is a primary concern of rangeland managers. In the Nebraska Sandhills, one of the largest contiguous grassland ecoregions remaining in North America, sandy textured soils are stabilized by fine root biomass from predominately warm-season grasses. Concern over the destabilization of the sand dunes has led to management approaches that seek to prevent disturbances, such as fire, that remove vegetation and expose bare ground. In 2012, the Sandhills experienced extreme drought conditions that coincided with the worst wildfire year on state record. This type of event is consistent with local concerns of the type of conditions needed to overcome the resilience of the Sandhills grassland to cause a lack of recovery of grassland vegetation and a loss of sand dune stability. To test this hypotheses, we assessed the recovery of aboveground grassland productivity at the Niobrara Valley Preserve following the Fairfield Creek Wildfire in burned areas compared to adjacent not burned areas. We also tracked changes in species composition to monitor any shifts in the plant community. Bison were not removed from the area and the drought continued for an additional six months following the wildfire. Two years following an extreme wildfire and drought event, grassland vegetation recovered rapidly, demonstrating the Sandhills grasslands are considerably more resilient than currently believed.

TECHNIQUES FOR IMPROVING SCIENTIFIC COMMUNICATION AMONG RANGELAND STAKEHOLDERS.

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Often there is a time lag between the generation of new scientific knowledge and its application on the landscape. Researchers are routinely taught to present their findings using specialized language, though technical terminology and formats may be less accessible to managers. Natural resource managers, scientists, and decision-makers must communicate effectively to achieve sustainable management. However, it is unclear that we fully understand the most effective communication techniques for management-oriented audiences. It is critical that we adopt communication techniques that support reception of emerging science. Based on data collection from scientific and managerial sources, we present communication techniques that enhance audience receptiveness to technical and scientific information. We examine the influence of value-loaded language on audience receptiveness to provide recommendations for effective outreach approaches. Our findings suggest that the use of value-based language (e.g. “positive” or “negative” primers) to introduce technical information leads readers to develop stronger reactions to technical information. Audience background (e.g. production or policymaking experience) also influences individuals’ responses to value-laden language. Traditional “neutral” presentation of scientific concepts may hinder, rather than support, adoption of new concepts and technologies. Audience values and training influences the most effective language approach in presenting technical information. We draw from survey data and existing literature to provide practical suggestions for communication for researchers, managers, and students interested in improving communication effectiveness. Ultimately, scientists must learn to employ non-neutral language to more effectively deliver outreach to attain extension applications of their science.

RELATIVE USE OF FERAL HORSES, LIVESTOCK, AND WILDLIFE AT SPRING LOCATIONS IN NORTHEASTERN CALIFORNIA.

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In northeastern California there are two distinct rangeland areas heavily populated by feral horses, the Devil’s Garden area managed primarily by US Forest Service and the East Lassen area managed primarily by the Bureau of Land Management. Feral horse herds in both locations have significantly exceeded appropriate management levels in recent years. This increase has prompted concern about resource degradation particularly associated with spring areas. In otherwise arid sage steppe rangelands, springs provide critical watering sources as well as wildlife habitat for sage grouse, deer, elk, pronghorn, etc. Our objective is to quantify the relative frequency, duration, and timing of use by horses, permitted livestock, and wildlife at spring locations. In turn, we assess to what extent there is competition between species for watering sites. We are correlating how varying levels of horse and/or livestock use affects spring site vegetation and riparian health standards. 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 July and October of 2015. Number of photos recorded per site ranged from 800 to more than 9000. All photos were visually assessed to record species present,

number of each species, and the time, date, and location of the observation. We present spring site occupancy data for two complete sampling periods, as well as results of corresponding vegetative cover, plant community, and bank alteration sampling. This information will aid public and private land management as it relates to feral horses in northeastern California.

BROWSE SPECIES OPTIMIZATION IN RESPONSE TO WHITE-TAILED DEER DENSITIES.

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Research on African shrub communities similar to those in South Texas suggests that heavy browsing stimulates regrowth with higher nutritional quality than un-browsed plants. Conversely, shrubs may allocate resources to defenses such as thorns, branching, or secondary compounds rather than to new leaves and twigs in response to herbivory. Based on the optimization hypothesis, our objective was to test the prediction that there may be an optimum white-tailed deer (*Odocoileus virginianus*) density at which regrowth and nutritional quality of blackbrush acacia (*Acacia rigidula*), twisted acacia (*A. schaffneri*), and spiny hackberry (*Celtis pallida*) can be maintained through browsing. Starting July 2014, we measured shoots and thorns annually on marked stems for each shrub species in 81 hectare enclosures containing 0, 25, 50, and 75 deer per km^2 on each of 2 ranches. A supplemental feeder was present in each enclosure. Each July and October, we removed leaf and twig samples from a different set of plants of each shrub species for nutritional quality analysis. Measurements and samples were taken within the white-tailed deer's browsing zone (50-100 cm from the ground) in each cardinal direction on the plants. The percentage of browsed twig tips increased linearly with increasing deer density from 0% with no deer to over 60% with 75 deer per km^2 . Preliminary results indicated that the number of non-lignified stems initially increased with increasing deer density, peaked at 50 deer per km^2, and then declined from 50 to 75 deer per km^2. Traditionally, managers try to achieve deer densities that are low enough to avoid causing undesirable changes in the plant community. A more efficient approach may be to manage for deer densities that optimize browse quality and quantity.

REGENERATION OF PONDEROSA PINE WOODLAND FOLLOWING SEVERE WILDFIRE IN THE NIOBRARA RIVER VALLEY.

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Over the last century, fire suppression has increased fuel loads and led to intense wildfire behavior in ponderosa pine (*Pinus ponderosa*) woodlands. In 2012, the Fairfield Creek fire burned over 60,000 acres in Nebraska's Niobrara Valley, including ponderosa pine woodlands. Our study examined: 1) post-fire survival of pine and encroaching eastern redcedar (*Juniperus virginianus*); 2) post-fire recruitment of pine, redcedar, bur oak (*Quercus macrocarpa*), and grassland across our 1,600 acre study area; and 3) factors limiting seedling establishment in a one-year seed addition study. Regardless of stand structure,

which varied from open savanna to pine/redcedar woodland, mortality for both pine and redcedar was almost complete. Out of an estimated 40,000 pines, less than 350 survived. In 2014, we classified our study area into pre-fire woodland density categories and established 400 random sampling points proportionally across the categories. At each point, we measured abundance of herbaceous vegetation, counted tree seedlings, and determined presence or absence of invasive species in a 10m diameter plot. Although there were clear patterns for grassland recovery and invasive Canada thistle (*Cirsium arvense*), we found less than 5 ponderosa pine and less than 20 redcedar seedlings in the 1600 acre study area. Finally, to examine factors limiting seedling establishment, we created 21 research plots where we planted native grasses, ponderosa pine, and eastern redcedar with and without competing herbaceous vegetation. These research plots included burned and unburned sites ranging from open grasslands to dense woodlands. Our results show poor recruitment of pine and cedar, regardless of natural or planted means. Even when viable seed was experimentally added and competing herbaceous plants experimentally removed, the lack of pine and redcedar recruitment suggests that the window of conditions allowing woodland recovery is small leading to a high potential for the conversion of the former pine woodland to grassland.

SPATIOTEMPORAL ASSESSMENT OF EMERGING ENERGY-DEVELOPMENT DISTURBANCE ON COLORADO PLATEAU RANGELANDS.

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Sustained increases in the scale and intensity of energy development activities have dominated land use trends on the Colorado Plateau, USA over the last several decades. These land-use types are characterized by soil surface disturbance, including total or partial removal of vegetative cover and physical alteration of the soil surface, resulting in decreased ecosystem productivity, increased soil erosion, habitat fragmentation, and other deleterious consequences. To better understand the magnitude and scale of these influences on Colorado Plateau ecosystems, we employed spatial toolsets and temporal remote sensing datasets (Landsat and MODIS). Estimates of spatial extent associated with oil and gas pad drilling and the rates of recovery after abandonment were evaluated. To account for how soil, geomorphic, and climatological factors may govern recovery, we used a multivariate environmental similarity surface and hierarchical approaches to group pads for analysis and find similar non-disturbed areas for comparison to gauge recovery progress. We found that pad development in more arid areas is of particular concern due to slow recovery times and high potential dust emissions. Oil and gas pad proliferation in recent years has been shown to represent significant carbon pool shifts, and is not yet fully understood in terms of ecosystem function over time. Development of wells in areas already disturbed by long term grazing, drought, and increased aridity due to climate change may have feedbacks beyond actual direct pad disturbance including wildlife habitat alterations, dust transport, decreased soil water storage, and soil erosion. Increased dust emissions are of particular concern regionally due to visibility impacts on recreation and tourism and dust deposition on adjacent mountain snow pack. Indeed, Colorado Plateau dust deposited on Rocky Mountain snowpack has been shown to decrease total annual run-off in the Colorado River Basin by as much as 5%.

COW-SIZE AND HERD EFFICIENCY RELATIVE TO WEATHER VARIABILITY ON WYOMING RANGELAND.

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Over the last several decades, cows have gotten bigger due to selection for maximum growth in sires and subsequent maternal traits and heifer retention. During this same period, temperature, drought frequency, and drought severity have also increased. Because cow-size influences maintenance costs, we assessed the effect of cow-size on weaning weight and efficiency in relation to drought on a semi-arid high-elevation ranch in Wyoming. From 2011 to 2014, we tracked 80 Angus x Gelbvieh cows for calf weaning weight, efficiency (considered as calf weight relative to cow weight), intake requirements, and potential herd sizes relative to 5 stratified cow weight classes (453 kg, 498 kg, 544 kg, 589 kg, and 634 kg). Weaning weights were adjusted to a 210-day and calf sex value. Cow size was a significant factor every year, with different cow sizes having advantages or disadvantages different years relative to weaning weight. Efficiency for the smallest cows (453 kg) was always greater than efficiency for largest cows (634 kg) ($P < 0.001$) and was greater in the driest year (0.41 ± 0.02) than efficiency of the largest cows in the wettest years (0.37 ± 0.01). Efficiency change between wet and dry years (ΔE), was 0.18 for the smallest cow size and 0.02 for the largest cow size. ΔE decreased consistently as cow size increased. These results indicate large cows (589 to 634 kg) did not maximize genetic potential in this Wyoming rangeland production environment when conditions are optimum or provide any advantage over small or moderate size cows (453 to 544 kg) across the drought gradient.

PASTURELAND ESD CONCEPTS AND CURRENT DEVELOPMENT.

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Bringing pastureland classification into an ecological site framework gives us the opportunity to build on the extensive experience of rangeland scientists and managers with this process. Unlike rangelands, pasture plant communities are dominated by naturalized species and are maintained by management, often within a complex landscape of agriculture, forest, and development. Current efforts to build a management-relevant classification system for pasturelands and other agricultural vegetation types begin with a quantitative landscape classification focused on the climatic, edaphic, and topographic variables that determine temperature, light, and water availability and thus potential plant species composition. Species distribution models, forage production models, and state and transition models of management alternatives and potential outcomes are then superimposed on this classification. Model results and management interpretations are based on field data and expert knowledge. Each step can incorporate either current climate or potential future climates. This process results in an ecologically-justifiable system for categorizing pasturelands that meets the needs of researchers and land managers, both now and into the future.

IDENTIFYING RELATIONSHIPS BETWEEN GRAZING PRACTICES AND RESOURCE CONDITION IN A WESTERN PINE FOREST.

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Managing Western pine forests for multiple-use is increasingly important for sustainable and efficient provisioning of ecosystem goods and services. A better understanding of the relationships among livestock grazing practices, timber and forage production, plant community composition, wildlife, and aesthetics is critical to reduce uncertainty and optimize management. To investigate relationships among 16 years of prior resource use and present forage production, pine seedling recruitment and plant community composition, grazed meadows and forests in 44 pastures were surveyed over two years in the Black Hills, SD across gradients of duration and timing of use, and herbage allowance expressed as the relationship between estimated herbage intake and estimated peak standing crop. Plant species richness was negatively correlated with herbage allowance (-0.31, n = 349, $P < 0.001$). Measured herbaceous production was positively correlated with estimated productivity (0.41, n = 246, $P < 0.001$). During two favorable growing season plant species richness and plant stature were more closely related to herbage allowance than to duration of use. Relationships quantified suggest that herbage allowance can determine stocking rates which balance livestock production and diversity in western pine forests.

WILDFIRE AND PRESCRIBED FIRE: EFFECTS ON SOIL ORGANIC CARBON.

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Wildfire and prescribed fire have different effects on soil organic carbon. Information from the SageSTEP project on soil chemistry relative to fire, including ecosystem rehabilitation effects on total carbon and nitrogen budgets in the Great Basin will be discussed.

FACTORS INFLUENCING WATER CONSUMPTION BY WHITE-TAILED DEER IN SOUTH TEXAS.

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Little is known about water consumption by white-tailed deer (*Odocoileus virginianus*). The highly variable rainfall and high temperatures that occur in South Texas have the potential to cause stress in animals that are unable to maintain water balance. Factors that could affect an animal's ability to maintain water balance include temperature, rainfall, body size, productive processes, diet, and activity level. This study was replicated on the Faith and Comanche ranches in Dimmit County, Texas. Both ranches contain one 81-ha enclosure with 60 deer and one supplemental feeder and another 81-ha enclosure with 20 deer and one supplemental feeder. Each enclosure has one centrally located water

trough which was covered with plywood during data collection. Five bucks and five does, individually identifiable by ear tags, of varying ages were selected in each of the 4 described enclosures. The amount of water consumed by the selected deer was monitored using a motion-activated video camera monitoring the digital readout from a scale supporting a water tub from which deer drank. Water consumption data were collected for one year and compared to rainfall, temperature, Palmer Drought Severity Index, productive processes, and deer density in order to determine the effects these variables have on water consumption. Preliminary data from the Faith Ranch study site indicated bucks in the 20 deer enclosure consumed an average 0.462 L·wk while bucks in the 60 deer enclosure consumed an average 1.191 L·wk. Faith Ranch does consumed an average 0.269 L·wk and 0.265 L·wk in the 20 and 60 deer enclosures, respectively. At the Comanche Ranch study site, bucks in the 20 deer enclosure consumed an average 2.988 L·wk while bucks in the 60 deer enclosure consumed an average 1.256 L·wk. Comanche Ranch does consumed an average 0.594 L·wk and 0.602 L·wk in the 20 and 60 deer enclosures, respectively.

FINE-SCALE TEMPORAL MODELING OF ELK (CERVUS CANADENSIS) HABITAT SELECTION.

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Most habitat selection studies explicitly acknowledge issues of spatial scale, but many do not fully consider temporal scale. Even when organisms exhibit clear diel behavioral patterns that coincide with changes in habitat preference, studies often ignore selection patterns finer than seasons. Using elk (*Cervus canadensis*), a species with crepuscular diel behavioral patterns, as an example, we sought to determine if modeling habitat selection at a diel temporal scale improved understanding of habitat selection more than simply modeling at a seasonal scale. We fitted 23 female elk in the Jemez Mountains of New Mexico with GPS collars and recorded location fixes every 5 - 6 hours from December 2012 to February 2015. To create biologically-valid temporal delineations for modeling, we used climatic data to partition seasons, and we observed elk behavior to determine major shifts in foraging behavior throughout diel periods. To model habitat covariates, we distributed circular sampling units systematically from a random origin and populated them with vegetation type, fire history, aspect, distance to water sources, and distance to roads, and predicted forage biomass. We modeled elk habitat selection with a bootstrapped resource selection probability function, using a negative binomal generalized linear model, by seasons (winter, spring, summer, fall) and by diel intervals (dawn-dusk, midday, night) within seasons. Diel models detected more detailed, novel, and some patterns contradictory to seasonal models. During dawn-dusk intervals, elk tended to select for grassland vegetation and low or high canopy cover. At midday, elk selected for forest vegetation types, recently burned areas, and areas with intermediate levels of herbaceous biomass. During the night, elk selected for areas with highest levels of herbaceous biomass, areas closer to water, against canopy cover, and recently burned areas. Our findings highlight the importance of accounting for fine temporal scales and behavioral patterns when modeling habitat selection.

BENEFITS OF SELECTIVE CHEMICAL CONTROL OF HUISACHE AND HONEY MESQUITE.

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Many ranch managers and landowners in the Southwest U.S. seem to have a continuous battle with honey mesquite (*Prosopis glandulosa*) and huisache (*Acacia farnesiana*). These species can create a closed canopy, near monoculture stand that dramatically changes the species diversity and species richness of a pasture or landscape. Various techniques including mechanical, chemical and fire have been developed and utilized over the last 50+ years to remove or suppress mesquite and huisache. Long-term viability of a treatment varies greatly across and within these treatment types. Controlling these unwanted species is one aspect all treatments have in common. Cattlemen have long recognized the value of a positive forage response following control. Past research has documented this forage response and longevity of treatment following chemical applications of root-killing or top-killing treatments. More recently, landowners are managing for multiple land uses including wildlife habitat and livestock production. This paradigm shift highlights the need for selective control of unwanted species, while not harming e plant species important for wildlife habitat. Since the introduction of Sendero® herbicide (aminopyralid + clopyralid) in 2012, research has focused on the value of chemical control of mesquite and huisache for improving habitat diversity and relative abundance of desirable woody species, grasses and forbs. Early data indicate honey mesquite, huisache, and several acacia woody species are highly susceptible to Sendero aerial broadcast treatments (>75% injury or mortality 2 YAT). Conversely, desirable tree species including Bumelia (*Bumelia lanuginosa*), lotebush (*Ziziphus obtusifolia*), live oak (*Quercus virginiana*), Guayacan (*Guaiacum angustifolium*), and Brasil (*Condalia hookeri*) exhibited tolerance (<20% initial injury, no death) to aerial broadcast applications of Sendero, and in many cases never exhibited herbicide symptomology following application. By using selective chemical solutions like Sendero herbicide, honey mesquite and huisache can be removed from rangelands to promote a healthy wildlife habitat capable of sustaining improved livestock production.

HISTORY AND BACKGROUND OF THE SOIL HEALTH MOVEMENT: INTRODUCING THE NRCS SOIL HEALTH DIVISION.

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Widespread adoption of soil health management systems has the potential to result in continental-scale, systemic improvements in environmental factors, farm resilience and productivity, as well as profitability. Concentrated efforts to improve soil health will thus provide significant return on the nation’s conservation investment. The new NRCS Soil Health Division was initiated to leverage resources, skills, technology, and partnerships nationally to facilitate increased implementation of science-based, effective, broad-acreage soil health management systems on the nation’s diverse agricultural lands. NRCS educational, technical, and financial assistance programs will be expanded and adjusted to implement key functions of the new Soil Health Division. These functions will include efforts

to provide advanced soil health technical training and education to stakeholders, to standardize and increase the use of publicly available soil health testing that leads to result-informed soil health management recommendations, to guide soil health management planning and implementation, and to monitor and adapt services for sustained, long-term adoption. Planned Soil Health Division activities and potential opportunities for collaboration will be discussed.

RIPARIAN RESTORATION: UNGULATE HERBIVORY AND MICROSITE CONDITION IMPACTS ON DECIDUOUS WOODY SPECIES ESTABLISHMENT AND GROWTH.

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Over the past decade, numerous intensive, large-scale riparian restoration projects focused on improving salmonid habitat have been established in the interior Pacific Northwest. In addition to in-stream restoration, these projects often include plantings of deciduous woody species in the riparian zone to increase shrub cover and shade. However, few studies have evaluated the factors that influence success of these enhancement plantings or their establishment and growth rates. Here we evaluate the effects of wild ungulate herbivory (elk, mule deer) and microsite conditions on the establishment and growth of deciduous woody species planted as part of a large-scale riparian restoration effort within the Starkey Experimental Forest and Range in northeastern Oregon. We tracked growth and survival of species both exposed to and protected from wild herbivores and under a range of micro-site conditions over 2 years. Results indicate that wild ungulate herbivory had measurable effects on seedling survival and height. Plants protected from ungulate browsing were significantly taller than unprotected plantings, and this pattern held for six of the seven species evaluated. Microsite conditions also influenced survival. Despite the extensive planting effort (>40,000 plants), plantings had minimal impact on overall shrub cover in the riparian zone. We discuss implications of our results for integrated ungulate management and current riparian restoration practices for salmonids in riparian ecosystems.

GAME SPECIES ASSOCIATED TO THE RANGE MANAGEMENT IN MEXICO.

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The future of the range management and livestock industry in Mexico is a matter of debate. The traditional use of land now goes to look for adjustments aimed to find new alternatives more efficient for obtaining energy in a sustainable way considering range management strategies that promote the multiple use of pasture in different ecosystems. Rangeland occupies approximately 51% of the earth's surface and supports different uncultivated vegetation types that can provide the requirements of life for native and domestic herbivores in a sustainable fashion. Range management is a synthesis discipline that draws from many different areas. Livestock cannot be permanently maintained on arid grazing lands, unless we use grazing systems that more closely approximate the type of grazing pressure applied by native game species. One basic consideration is that big-game herds feed selectively and keep moving and thus do not put sustained pressure on any one area. Since 2000, the Mexican legislation

allows financial investment in land that can be used for the development of wildlife, as an alternative for the biodiversity conservation. Species such as white-tailed deer, bighorn sheep, mule deer, wild turkey, ocellated turkey, collared peccary, and others, have thrived in rangelands, allowing better use of land and generating new economies. The rangelands of Mexico include several types of vegetation such as deserts, grasslands, shrubs, forests, and riparian areas, where forage is produced only in favorable localized areas. All of these lands have a variety of uses, of which the support of livestock is only one. Many semi deserts and mountains have incomparable values as wilderness recreation lands and homes for rare forms of wildlife.

MANAGEMENT OF INVASIVE OLD WORLD BLUESTEMS TO RESTORE NATIVE GRASSLANDS.

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Old World Bluestems (*Dichanthium annulatum and Bothriochloa ischaemum*; OWB) are classified as invasive plant species that are encroaching native rangelands in Texas, especially in the south Texas region. Historically, OWB were planted for grazing on rangelands and erosion control along roadsides; however, they provide poor quality wildlife habitat and livestock forage. Currently, no individual control method has proven to effectively manage OWB. Therefore, the objective of this study was to evaluate combinations of treatment methods in triplicate plots to manage these invasive grasses. We used primary (summer fire, glyphosate, or nicosulfuron + metasulfuron methyl, and control) followed by secondary treatments (plowing, mowing, plowing + reseeding with a native mixture, or fertilizer, and a control) in a factorial design (4 × 5) to integrate multiple management practices and determine the most effective treatment combination. The experiment was conducted at three different sites, in two counties, representing different soil types and climatic conditions in south Texas. Cover and botanical composition of plots and yield of OWB were estimated bimonthly over 2 years to determine which treatment combinations were the most effective. Cover was initially decreased by treatments, but after 16 mo only primary treatments followed by plowing, mowing, or plowing + seeding with a native mixture had decreased ($P < 0.05$) cover. After 16 mo, total herbage mass (kg ha-1) and OWB (% of cover) declined ($P < 0.05$) with primary treatments followed by plowing or plowing + reseeding. After 16 months of observation, OWB is best controlled with these primary treatments followed by plowing. Alternative management practices which control OWB without destroying other native plant species are necessary.

RANGELAND SOIL HEALTH: SUMMARY AND DISCUSSION ON MEANING AND DIRECTION FOR RANGELAND MANAGEMENT.

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This paper will summarize and synthesize the papers in this symposium. The co-authors will then facilitate a discussion focusing on implications for rangeland soil science and management. Managing soil health is a critically important challenge for all of the nation's lands, including rangelands. Soil health affects and is affected by virtually every management action. In some cases these effects are direct while in others they are indirect through vegetation management. Most managers focus solely on managing the plant community, and assume that a healthy, productive plant community will improve soil health through compaction-busting root growth, soil organic matter inputs, protection of the soil surface from wind and water erosion and evaporation, and keeping soil temperatures in a favorable range for soil biotic activity. The papers in this symposium have in many ways supported these assumptions. However, they have also demonstrated how an understanding of rangeland soil processes can often improve our ability to manage rangeland ecosystems, increasing production while reducing runoff and erosion. They have shown how soil health can sometimes be used as an early warning indicator of changes in rangeland ecosystem resilience. Finally, they have illuminated the tremendous gaps in our understanding of rangeland soil health, which is also reflected by the literature. We look forward to a fruitful discussion of how the soil health movement can and should influence rangeland management. We expect the discussion to reflect a broad variety of views, based on the diversity of knowledge and experience represented by both the speakers and the membership of the Society for Range Management, which provided supporting comments for promoting soil and rangeland health at a special hearing titled "The benefits of promoting soil health in agriculture and rural America" by the House Committee on Agriculture, Subcommittee on Conservation, Energy and Forestry, held on September 18th, 2014.

HETEROGENEITY OF AN INVADED TALLGRASS PRAIRIE: EVALUATION OF ALTERNATIVE GRAZING STRATEGIES WHILE PATCH-BURNING.

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Grasslands are complex ecosystems which are maintained by an interplay of abiotic and biotic factors. These factors work at different spatial and temporal scales to create heterogeneity in plant community structure and composition. Patch burn grazing is used to create a fire-grazing interaction as grazers preferentially graze on patches of the landscape that have been recently burned. This type of management can increase heterogeneity within managed grasslands at certain scales. In this study, conducted in Iowa's Grand River Grasslands, we quantified structural heterogeneity at different scales in tallgrass pastures invaded by tall fescue (*Schedonorus arundinaceus*) and managed with patch burn grazing under two different grazing strategies. The grazing strategies we compared were 1) season-long stocking (April – September) and 2) intensive early stocking (April – July). Each treatment was replicated twice (for a total of four pastures) in tallgrass prairies heavily invaded with tall fescue, an exotic grass. To create a fire-grazing interaction, each pasture was split into three patches. One patch was burned annually. Cattle were stocked at 2.5 AUM/ha and allowed free access to all patches. Data were collected early, late, and after the growing season for two years to determine how heterogeneity changed throughout the year. We measured visual obstruction, plant height, and canopy cover of vegetation every 3-m on 300-m transects permanently located in each patch of each pasture. In this paper, we discuss how differences in stocking rate and duration within a patch burned landscape influenced

heterogeneity at different scales and how this heterogeneity changes through the year. We consider how the patterns and processes that create heterogeneity can affect the ability to manage for heterogeneity in invaded grasslands and the implications for land management.

A COMPARISON OF TWO VEGETATION HEIGHT METHODS FOR GREATER SAGE-GROUSE HABITAT SUITABILITY EVALUATIONS.

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Conservation of Greater Sage-Grouse (*Centrocercus urophasianus*) habitat has become an important issue for U.S. federal land agencies as habitat is lost or degraded across the American West. This drives a need for data collection in sage grouse habitat to assess the habitat status. Published in 2015, the BLM technical reference *Sage-Grouse Habitat Assessment Framework* (HAF) describes three categories of habitat suitability (suitable, marginal, and unsuitable) in part defined by height of sagebrush (*Artemisia* spp.), grasses, and forbs. The HAF also recommended a method for measuring vegetation heights. However, existing monitoring efforts like the BLM Assessment, Inventory, and Monitoring (AIM) program and the NRCS National Resources Inventory use a different method for measuring vegetation height—described in volume I of the *Monitoring Manual for Grassland, Shrubland, and Savanna Ecosystems*. We recognize that method of measuring vegetation has strengths as well as shortcomings, for example the HAF method may under-represent sparsely distributed, small plant species and the *Monitoring Manual* method may under-represent species that cover a small percentage of the sampling unit. As a result, our objective was to test how the results of the *Monitoring Manual's* vegetation height method compared to the HAF's height protocol. We compared vegetation height measurements for shrubs, forbs, and grasses using both methods in southern New Mexico, the BLM San Luis Field Office in Colorado, and the BLM Bruneau Field Office in Idaho. In many cases, we found differences between the two vegetation height methods to be minimal. We therefore conclude that *Monitoring Manual* vegetation height data are likely sufficient for evaluating sage grouse habitat suitability with the HAF. Where compatible vegetation height data already exist or are being gathered, these data should be able to satisfy the requirements for HAF habitat suitability assessments.

USE OF HERBICIDES TO RESTORE RANGELAND INFESTED WITH INVASIVE EXOTIC WOODY PLANTS.

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Exotic, invasive woody plants are a threat to rangeland ecosystems by disrupting hydrologic and nutrient cycles, displacing native plant species and reducing biodiversity at multiple trophic levels. Mechanical controls can be effective on some species, but high site disturbance caused by these methods often proliferates invasive plants and profoundly alters desired habitats by disrupting structure and function of rangeland communities. In semi-arid and arid climates, soil disturbance can provide abundant and

long-lasting loci for invasive herbaceous species establishment. Biological controls are effective on some invasive woody species locally, but they tend to have had limited effectiveness in reducing adverse impacts on a larger scale. Historically, chemical control of exotic woody species has resulted in non-target damage to native plant species, depending on the herbicides used and application technique. Recent advances in herbicide chemistry and application techniques enable selective and targeted invasive woody plant control, while mitigating their adverse impact on desired species and rangeland ecosystems. These advances include: saltcedar (*Tamarix* spp.) control in riparian areas by mechanical removal followed and individual plant treatment (cut surface applications) of Garlon® 4 Ultra herbicide (triclopyr butoxyethyl ester). Additionally *Miconia* spp. control in Hawaiian forests with aerial applications of Milestone® herbicide (aminopyralid triisopropolamine) using a drop nozzle from a helicopter or an herbicide ballistic technology application provide precise control of the invader with minimal impact to the landscape. In the east, Virginia pine (*Pinus virginiana*) control in longleaf pine forests with Milestone herbicide or Garlon 4 herbicide maintains natural forests. Knowledge of herbicides and application methods enables land managers to select the best tools for rangeland restoration objectives. Herbicides often act as a catalyst for desired change in rangeland communities. This desired effect can be sustained when herbicides are used in conjunction with other practices in a long-term programmatic approach.

IMPLICATIONS OF PASTURE AREA, GRAZING STRATEGY, AND SITE ON LESSER PRAIRIE-CHICKEN HABITAT SELECTION AND VEGETATION.

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The Lesser Prairie-Chicken (*Tympanuchus pallidicinctus;* hereafter LEPC) is a grouse species endemic to the grasslands of the southern Great Plains. Population declines throughout the species distribution has resulted in conservation concern and action. The vast majority of the species range occurs on private grazed lands. Therefore, knowledge of LEPC population responses to livestock grazing strategies would aid in conservation planning. We investigated the effects of pasture area and grazing strategy on LEPC habitat selection and nest survival across environmental gradients (i.e. precipitation and biomass production) among four sites in Kansas and Colorado. LEPC females were captured, marked (22g SAT-PTT or 17g VHF), and monitored. Grazing data were collected via producer correspondence and vegetation surveys. LEPC breeding season habitat selection and nest site selection were evaluated using resource probability functions (RSF) and vegetation response (means and coefficients of variation) at the point level was modeled using linear regression. Positive influences on vegetation characteristics (grass height, grass cover, biomass, etc.) and subsequent LEPC habitat selection were maximized at moderate levels of grazing intensity (1.9-2.95 ha/AUM) and greater pasture areas (>300 ha). Benefits of the interaction between biomass production and grazing strategy (quantity and timing of deferment) require regional and site-by-site consideration. These findings indicate the relative importance of grazing disturbance to functional grasslands and the potential for symbiosis between beef production and LEPC viability within grazed lands.

ECOLOGICAL SITE DESCRIPTION (ESD) SUPPLEMENTS FOR CHARACTERIZING WEATHER AND MICROCLIMATE VARIABILITY IN RANGELAND RESTORATION PLANNING.

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Our current understanding of ecosystem resistance and resilience to weed invasion suggests that ecological thresholds exist below which weedy species can dominate, and above which more desirable perennial species dominate. Mapping of seedbed microclimate and correlation to existing patterns of post-disturbance vegetation would provide a mechanistic model in support of resistance and resilience concepts, and quantitative information in support of the State and Transition Models (STMs) that underlie Ecological Site Descriptions (ESDs) for sagebrush/bunchgrass plant communities in the northern Great Basin. Resistance to disturbance and resilience of native and seeded-non-native plant communities follow topographic patterns associated with soils, slope, aspect and elevation. These patterns of post-disturbance vegetation appear to be correlated with soil and topographic effects on seedbed temperature and water relationships. We used long-term weather data and microclimatic modeling to characterize topographic effects on post-disturbance seedbed conditions and the subsequent distribution of both planted and weedy species. This information may improve the utility of ESDs for rangeland restoration planning and provide quantitative information on topographic and elevational thresholds of ecological resilience.

WEATHER THRESHOLDS FOR SUCCESSFUL SEEDLING ESTABLISHMENT.

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In semiarid rangelands, initial seedling establishment is a key, weather-sensitive demographic bottleneck in restoration of perennials such as sagebrush. We assessed differences in physiological responses of big sagebrush (*Artemisia tridentata*) to weather among eleven seed sources that varied in subspecies, cytotype, and climate-of-origin following outplanting. Preliminary results showed that seasonal timing of mortality was associated more with minimum temperatures rather than water deficit. There were also large differences in physiological, freezing-temperature thresholds among subspecies and cytotypes, particularly in the temperature causing cellular ice formation than for the temperature causing 50% loss of photosynthetic function. In contrast, physiological responses to water did not correspond to survival patterns. Our findings on the importance of minimum temperature thresholds for restoration plantings in these water-limited rangelands are corroborated by a related study that found that matching minimum temperatures of seed source and seeding sites enhanced restoration success in 24 historic, large-scale seedings done from 1987-2010 on wildfire areas. Sagebrush seeds were transported from high to low elevations in these seedings, ie. cool/wet-adapted seed sources were imported into warmer and drier burned areas. Daymet weather simulations over the >100,000 acres and decades of these seedings revealed that much colder and wetter weather, particularly 3-4 years after burning and seeding, led to greater establishment. These findings lead to the hypothesis that introduction of cool/wet-adapted seeds for restoration or rehabilitation of burned areas has caused sagebrush establishment to favor cool/wet weather, even though low-temperature thresholds are a key

limitation to seedling survival. Climate and particularly weather thresholds are clearly important factors for post-fire vegetation establishment. Our study used statistical methods and weather data to reveal weather thresholds useful for modeling, and can be adopted to evaluate the many other seedings and plantings that are increasingly invested in to restore sagebrush-steppe rangelands.

WILDLIFE DIVERSITY AND UTILIZATION IN PAIRED RESTORED NATIVE PERENNIAL AND UNRESTORED ANNUAL GRASSLANDS IN CALIFORNIA'S CENTRAL VALLEY.

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In California's Central Valley 98% of native grasslands have been destroyed or degraded due to invasion, farming, development, and fragmentation. Grassland restoration is generally assumed to provide improved wildlife habitat, increasing wildlife abundance and diversity relative to unrestored, invaded annual grasslands. To investigate that assumption, we compared relative wildlife utilization at paired restored and unrestored (control) grasslands at four locations in Yolo and Sacramento counties using live traps, camera traps, snake boards, and observational surveys in four seasons from 2014-2015. Restored sites were planted with native perennial grasses 10-20 years ago but are now invaded by Mediterranean annual grasses and forbs. Control sites contained similar non-native plant species assemblages but did not have any native grass cover. In general, mouse, vole, and snake utilization was higher at control relative to restored sites across all four seasons. Raptor surveys in three seasons revealed greater species diversity, foraging time, and attack rates at control sites as well, likely in response to greater rodent abundance. Within sites, species-specific responses were related to vegetative cover and percent bare ground. For example, *Peromyscus maniculatus* (deer mouse) was associated with high bare ground and low vertical cover, regardless of site type (restored/control). Substantial changes in rodent community composition could also be achieved over short periods of time (< 3 months) by manipulating vegetative cover. These results reveal that native grassland restoration may not automatically confer increases in habitat utilization or species diversity, and rapid changes in vegetative structure could strongly impact species composition, suggesting a more nuanced approach could be required for the restoration of desired biodiversity.

IMPACTS OF ANTHROPOGENIC NOISE AND TRAFFIC FROM EAGLE FORD SHALE EXPLORATION ON QUAIL HABITAT USE.

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The northern bobwhite (*Colinus virginianus*) and scaled quail (*Callipepla squamata*) have been declining across their ranges for decades due to habitat loss. Since 2008, the Eagle Ford Shale has been rapidly developed in nearly 30 counties in Texas. Currently, there is little knowledge regarding how disturbance from the development of the Eagle Ford Shale might impact bobwhite and scaled quail populations in

South Texas — one of the few remaining strongholds for quail populations in the US.The objective of this study is to determine how bobwhites and scaled quail respond to localized oil-and-gas disturbance. Our study is located on 2 private ranches in Dimmit and Maverick counties and consists of 2 areas along an oil-and-gas exploration corridor (treatment) and 2 areas along corridors where no exploration activities have occurred (control). Ambient sound levels and sound levels from point sources of anthropogenic noise were recorded using a sound level meter. We also measured traffic rates using single road tube accumulators. Metrics of quail habitat use were collected using radio-telemetry.We will use these data to compare site fidelity and home range size of bobwhites and scaled quail between treatments. In addition, we will create a spatial map depicting average sound levels in treatment areas. We will calculate direction of quail dispersal from treatment corridors for quail, and we will develop selection functions to determine if quail are avoiding treatment corridors. Through this study, we hope to identify the effects of intense oil-and-gas disturbance on quail within some of their last un-fragmented habitat in the United States.

DOES SUPPLEMENTAL FEED ALLEVIATE ENVIRONMENTAL PRESSURES ON ELK PRODUCTIVITY RATES?

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Several western states have documented a decline in elk productivity rates in some areas since the 1970s. Multiple hypotheses have been developed, most of which focus on predators, range conditions, and weather patterns. Supplemental feed, which presumably reduces environmental effects, is often necessary to maintain or enhance population growth rates. Several elk herds in the Greater Yellowstone Ecosystem are fed during winter to alleviate interactions with livestock, reduce damage to stored crops, and to manage for high elk numbers. Despite many decades of feeding elk, the effect of supplemental feeding on population dynamics has not been examined. We used linear regression to assess how the presence of feedgrounds, snowpack, summer rainfall, indices of grizzly bear density and wolves per elk, elk population trend counts, brucellosis seroprevalence, and survey date were correlated with midwinter calf:cow ratios, a metric correlated with population growth, from 1983–2010 from 12 ecologically similar elk herd units (7 fed and 5 unfed) in Wyoming, USA. Our statistical approach allowed for tests of the hypotheses that supplemental feeding had positive effects on calf:cow ratios and reduced sensitivity of calf:cow ratios to bottom-up limitation relative to top-down limitation from native predators. Calf:cow ratios generally declined across all herd units over the study period and varied widely among units with feedgrounds. We found no evidence that the presence of feedgrounds had positive effects on midwinter calf:cow ratios in Wyoming. Further, fed elk showed stronger correlations with environmental factors, whereas calf:cow ratios for unfed elk showed stronger correlations with predator indices. Although we found no consistent association between winter feeding and higher calf:cow ratios, we did not assess late winter mortality and differences in human offtake between fed and unfed regions, which remain a priority for future research.

OLD WORLD BLUESTEM INVASION: EFFECTS ON WILDLIFE AND NATIVE PLANT COMMUNITIES.

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Old World Bluestems (OWB), a group of non-native, invasive, warm-season grasses, have been extensively planted throughout the Central and Southern Great Plains for livestock forage production, perennial vegetation cover in the Conservation Reserve Program and erosion control. Examples of these grasses include Caucasian (Bothriochloa bladhii), yellow (Bothriochloa ischaemum) and Kleberg's (Dichanthium annulatum) bluestem. Each of these species have escaped from their planted boundary and invaded native grasslands, altering multiple trophic levels throughout their invaded range. Within the past 15 years research has focused on the effect of these grasses on various taxa rather than their use in agricultural production. Old World bluestems reduce native plant species diversity and seed bank composition, as well as change soil microbial communities in a manner that inhibits colonization by native grasses. Effects of exotic grass invasion on structural attributes of plant communities appear to vary with the invading species and the extent of the invasion, resulting in wide ranging effects on wildlife populations. Rodent communities in central Texas were found to have reduced species richness and abundance in OWB monocultures compared to habitats dominated by native grasses. In a mixed-grass prairie habitat in south central Kansas, bird species richness, bird abundance and food availability (arthropod biomass) were significantly lower in OWB monocultures than in native rangeland. Importantly, OWB monocultures had lower heterogeneity of vegetation structure, as well as fewer forbs than the native rangeland sites, potentially contributing to the reduced species richness and abundance of the grassland birds. Invasion by exotic grasses in the South-central United States has been proposed as a contributing factor in the decline of grassland birds; however, at a population level, individual bird species exhibit differing responses to the presence of exotic grasses and the level of invasion.

FIRE ECOLOGY AND BRUSH MANAGEMENT.

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Much of the southern Great Plains in the United States, including Texas, were once vast open grasslands that have become dominated by woody plants ("brush") such as mesquite (Prosopis) and juniper (Juniperus) in the last 100 years. These species have increased as a result of numerous factors including increased seed distribution via livestock consumption and fecal deposition of viable seeds, and overgrazing by livestock that has reduced frequency of natural fires and limited the competitive ability of grasses against emerging brush seedlings. This vegetation shift has become so pervasive that brush threatens grass-dependent livestock production and grassland-dependent plant and wildlife species. Concurrently, different wildlife species and different income sources such as recreational hunting for shrub-dependent wildlife have developed that further threaten the impetus for restoration of grassland function. This trajectory will continue without anthropogenic brush management intervention. The re-introduction of fire via prescribed fires may have a role but has severe limitations related to frequency and precision of application, and desired effect (e.g., resprouting shrubs like mesquite are only temporarily suppressed). Simply put, the frequency and intensity of fire required to mimic pre-

settlement fire regimes that limited brush invasion may not be possible in many rangeland areas, especially as human population growth into rural areas increases. This paper will summarize the responses of brush, grass and soils to fire and point to possible management solutions with fire and other brush management treatments that offer the best chance to achieve agricultural production, recreation and ecological restoration goals.

SUSTAINING AND ENHANCING WETLAND BIODIVERSITY AND ECOSYSTEM SERVICES ON RANCHLANDS.

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Grazing lands occupy 25% of the global land surface and intersect with numerous wetland resources. Wetlands embedded in grazing lands provide several well-known ecosystem services, including water and forage for livestock, high primary productivity, carbon sequestration, nutrient retention, flood amelioration, and climate buffering. In addition, wetlands are known for their high biodiversity and provide habitat for organisms critical to food webs and pest suppression. A key question is how to manage wetlands embedded in agricultural lands to sustain and enhance biodiversity and ecosystem services. In subtropical south central Florida, grazing landscapes are dotted by ephemeral wetlands which comprise 15-25% of these grasslands. We report here on how these wetlands are biodiversity hotspots within the grassland matrix. Wetland studies at the at MacArthur Agro-ecology Research Center (MAERC), a division of Archbold Biological Station, have recorded 180 plants, 181 insects, and 31 amphibians and fish as well many wetland birds, including nine species listed as threatened or endangered. These productive, isolated wetlands, numbering more than 600, support higher trophic levels. For example, MAERC contains one of the highest densities of Red-shouldered Hawks ever recorded in the science literature, and the landscape supports numerous apex species, including crested Caracara, barn owls, river otters, and bobcats. Our study results demonstrate that wetland connectivity via ditches, management of hydrology, and pasture management intensity are key drivers of wetland community diversity and composition, and other ecosystem services such as forage production and greenhouse gas dynamics. We also address how threats to wetland ecosystems on ranchlands including feral hogs, drainage, and altered fire regimes must be addressed to sustain and enhance wetland biodiversity and ecosystem services on ranchland whilst maintaining economic viability.

WHAT DOES SOIL HEALTH MEAN TO A RANCHER? PERSPECTIVES IN GRAZING MANAGEMENT FOR SOIL HEALTH AND USE OF ASSESSMENT TOOLS INCLUDING THE RANGELAND HEALTH ASSESSMENT.

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What does soil health mean to a rancher? This presentation will outline a few of the many different perspectives that ranchers have when the words, “soil health” are mentioned. The National Grazing Land Coalition is a nationwide consortium of individuals and organizations working together to maintain and improve the management and the health of the Nation’s grazing lands. The NatGLC is founded on

the principles of voluntary action by those who own and manage grazing lands, and is well suited for taking the pulse on rancher perspectives regarding soil health through their experience in applying grazing management strategies that influence soil health. NatGLC also has interest in the development and use of grazing land technology and conservation tools that best assist ranchers in managing grazing lands. Tools that assist grazing managers whose objectives include improving or maintaining soil health will be discussed including the rangeland health assessment and ecological site description.

DERIVING EMPIRICAL BENCHMARKS FROM EXISTING MONITORING DATASETS FOR RANGELAND ADAPTIVE MANAGEMENT.

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Under adaptive management, goals and decisions for managing rangeland resources are shaped by requirements like the Bureau of Land Management's (BLM's) Land Health Standards, which specify desired conditions. Without formalized, quantitative benchmarks for triggering management actions, adaptive management is challenging and subjective. Traditionally, monitoring and management benchmarks have been derived from key sites or expert opinion. However, these techniques are limited by time, scale, subjectivity, and may inform only on conditions that are no longer achievable. Empirical approaches for developing benchmarks for different indicators based on a growing corpus of rangeland monitoring data may provide a useful and defensible alternative. We describe use of BLM Assessment, Inventory, and Monitoring program data from northern California to establish quantitative monitoring benchmarks for BLM's Land Health Standards. Bare ground, canopy gap, and perennial grass cover were explored as testbed indicators. Benchmarks are necessarily tied to land potential units (*e.g.*, ecological sites) and can be used to assign categories (*e.g.*, "meets objectives" and "does not meet objectives"). When an indicator's value range is broadly distributed and encompasses potential reference conditions, as with bare ground and canopy gap, simple quantiles may be sufficient for setting criteria. For indicators with narrow and skewed distributions due to disturbance or management legacies, (*e.g.*, perennial grass cover), this technique has limited application. Comparing conditions across land potential units is simpler with categories than with numerical values. Additionally, summarizing areas of interest by the proportion of sample units meeting success criteria makes clear that, although an area may overall meet management objectives, portions may not. This approach has potential for broad application, particularly with existing and ever-growing quantitative monitoring datasets available, and complements historic approaches which remain viable options in some cases.

TANGLEHEAD: INVASION BY A DECREASER?

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Tanglehead (*Heteropogon contortus*), a native perennial C4 grass, historically was considered a decreaser throughout southern Texas. In the past ~ 20 years, tanglehead has increased dramatically, especially in the Texas Coastal Sand ecoregion; causative factors likely include a combination of changes in land use, climate and fire. Tanglehead can produce over 4000 kg ha-1 with foliar cover exceeding 100% and near-100% residual dry matter cover; adult plants are long-lived and seed production is prolific. When native vegetation is replaced by dense tanglehead monocultures, wildlife habitat is degraded and livestock grazing value is reduced. There is growing evidence that invasive grasses can affect ecosystem processes, including nutrient and energy exchange as well as soil microbial communities. Plant communities that are (i) dominated by tanglehead, (ii) a mixture of tanglehead and native species, or (iii) dominated by native species differ with respect to soil microbial biomass (carbon and nitrogen) and microbial community composition and structure; these differences, however, are temporally-dynamic. Prescribed fire in the spring can kill up to 60% of adult tanglehead plants but removal of residual dry matter allows for substantial seedling recruitment (> 1,500 seedlings m-2). Freshly-collected and 2-year old seeds have high viability (> 90%) and germination (> 80%). However, viability and germination of buried seeds decline to ~20% after years; thus, tanglehead does not form a persistent seedbank, and management practices that promote seed burial for at least 2 years may be effective. The combination of summer-prescribed fire followed by herbicide (Arsenal® or Spike®) can reduce adult tanglehead plant density for at least 2 years; single-treatment management practices (prescribed fire; herbicide; discing) are less ineffective.

SOIL HEALTH, ECOLOGICAL SITE DESCRIPTIONS AND THE STATE AND TRANSITION MODEL.

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Management of rangeland ecosystems is challenged by high heterogeneity in soil-geomorphic attributes, low and variable precipitation, and ecosystem dynamics prone to threshold or hysteresis type transitions. Available resources for managing rangeland landscapes are typically low, particularly when compared to the land area occupied. The NRCS Ecological Site Information System and associated Ecological Site Descriptions (ESDs) and State and Transition Models (STMs) provide information and tools to help address these management challenges. ESDs classify landscapes based on soils, topography, and climate. STMs are imbedded within ESDs and provide descriptions of site dynamics, including putative ecological states, transitions between states and restoration pathways. Development of ESDs is primarily focused on patterns in soil-vegetation relationships. Although some soil health parameters are described for the reference state (e.g. rangeland health reference sheets), they are not often fully integrated into ESDs. In many rangeland ecosystems, ESDs can provide context for interpreting soil health data, whilst changes in soil health indicators over time can inform rangeland managers of at-risk of transitioning to an undesired state. As an example of how soil health indicators can add value to rangeland ESDs, we provide results from a recent interagency STM workshop where we successfully incorporated biological soil crusts into a STM from the Colorado Plateau region of the southwestern U.S. In this example, loss of biological soil crusts help define an at-risk phase indicating risk of transition to an undesired state. In rangeland systems of the U.S., land-use change and intensification is occurring at astounding rates. Successful restoration of rangeland ecosystems following soil disturbance will likely need to address soil loss and degradation. Integrating soil health

concepts and ESDs will improve our understanding of how soil quality varies over space and time in rangeland ecosystems and help facilitate adaptive management of rangeland landscapes in the US and globally.

BIOMASS AND NET PRIMARY PRODUCTIVITY ESTIMATION USING HIGH RESOLUTION SATELLITE IMAGERY IN ANDEAN PASTURES.

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Biomass and net primary production can be quantified at the landscape level using a combination of field methodologies and remote sensing. Spatial models can be very useful to acquire this information. Although there are several methodologies that have been developed at regional and global scales, there are very few studies that assess biomass and net primary production using very high resolution imagery. Knowing the good fit between vegetation indices and photosynthetic processes, this study aimed at developing methodologies to integrate field data with remote sensing and landscape ecology approaches to quantify biomass and net primary production in bofedales (high altitude rangelands) in the Andes. To achieve our objectives, 13 bofedales were selected in the Andes region near La Paz (Bolivia). Pleiades imagery (2 m-resolution) and LANDSAT (15-m resolution) were used to calculate vegetation indices. Daily biomass data were estimated using a logistic function based on the interception of photosynthetically active radiation, thermal time and radiation use efficiency (RUE). The NPP was considered as 0.45 of RUE. Simulated and field data were compared using a linear regression and then compared to satellite imagery vegetation indices values. Vegetation indices values from satellite imagery showed a significant relationship (Pleiades, r^2=0.405, $p<0.001$; LANDSAT, r^2=0.650, $p<0.001$) with biomass and net primary production. Our results show that it is possible to quantify biomass and net primary production using satellite imagery. The results from the high resolution imagery (2 meters) show the value and importance of considering spatial heterogeneity when collecting field data in order to improve spatial models and get better estimators.

SOIL, SEEDBANK, AND SPECIES ESTABLISHMENT DYNAMICS INFLUENCING EAGLE FORD SHALE RESTORATION.

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Topsoil supports soil microbial communities; links abiotic and biotic components of ecosystems through nutrient cycling and energy flow; and provides a source of seeds for future restoration needs. Topsoil is

vulnerable to disturbance associated with energy production. A common management recommendation is to stockpile topsoil for future use. Greenhouse studies of seedbank dynamics of stock-piled topsoils over an 18-mo period suggest that variability in seedling emergence is more closely related to the season when a stockpile was created and then sampled, as well as the immediately-preceding climatic conditions, than the age of the stock-pile per se. In general, seedbank species diversity was unaffected by sampling time and depth and species richness and numbers of emerged seedlings decreased with increased depth in the stock-pile. In comparisons of soil microbial communities between stockpiles and adjacent undisturbed intact soils, microbial community size decreased with increasing sample depth in undisturbed soil but did not change by depth in stockpiles; furthermore, microbial community size was generally smaller at a 0-10-cm depth in stock-piles compared to intact soil. Microbial communities also generally differed in winter months and summer months. Stripping and stock-piling topsoil generally results in loss of spatial organization of microbial biomass. These factors are important considerations in restoration practices that involve topsoil. For example, following pipeline construction topsoil can be mixed with subsoil, creating mixed soil with characteristics that can be unfavorable for plant growth. Chances for restoration success can be improved by ameliorating harsh environmental conditions at the soil surface use mulching material that reduces extremes in soil surface temperature and can reduce soil water loss, two conditions that are important in seed germination and early seedling establishment. Humic substances have minimal effects on early seedling establishment and on soil nutrients 26 months post application. Selection of locally-adapted species is essential.

EVALUATING NEW HERBICIDES FOR DALMATIAN TOADFLAX (*LINARIA DALMATICA)* CONTROL.

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Dalmatian toadflax (*Linaria dalmatica* [L.] Mill.) is an invasive weed of northeast and western North American rangelands known for displacing desirable communities and reducing forage, particularly following disturbance. Managers typically use herbicides to manage toadflax populations and prevent spread. This experiment was designed to complement a separate study comparing herbicide with targeted sheep grazing. Our objective was to evaluate Dalmatian toadflax control with four herbicides alone and in combination, at the same rates, applied in either fall or spring. We applied herbicides in late fall 2013 and late spring 2014. Fall treatments generally reduced toadflax cover better than spring treatments in 2014 ($P < 0.0001$). In midsummer 2015, 21 months after treatment (MAT; fall application) and 13 MAT (spring application), chlorsulfuron+aminocyclopyrachlor reduced toadflax biomass by 80% compared with the check ($P = 0.07$). Fall treatments, irrespective of herbicide, reduced toadflax density and increased perennial grass biomass compared to spring treatments ($P < 0.03$). Treatments containing aminopyralid resulted in the greatest perennial grass biomass ($P < 0.0001$). Where cheatgrass was abundant prior to treatment, herbicides that reduced toadflax were associated with cheatgrass biomass increases as high as 400% ($P < 0.0001$). Managers should consider recovery potential of an invaded site prior to vegetation treatments. Where perennial grass recovery is likely, fall treatments may provide most consistent toadflax control with the least desirable species damage.
Chlorsulfuron+aminocyclopyrachlor provided best control in our study while retaining perennial grass biomass similar to the non-treated check.

MODELING WETLAND EPHEMERALITY UNDER CLIMATE CHANGE: IMPLICATIONS FOR AMPHIBIAN BIODIVERSITY AND GENE FLOW.

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Climate change, a major landscape stressor, is predicted to substantially alter ecosystem characteristics. In semi-arid regions where water availability is a crucial concern, wetlands constitute a critical, though highly sensitive and dynamic, ecosystem component. Altered temperature and precipitation regimes under climate change may affect wetland ephemerality, or the persistence of wetlands across the growing season. Our research combines remote sensing, field observations, and model-building to develop a novel, cost-effective, and large-scale method for relating the effects of climate change to wetland ephemerality. By using field observations to train remotely sensed data, we classified wetland ephemerality in the Plains and Prairie Pothole Region, a highly productive yet sensitive ecosystem, under a range of climatic conditions representing potential changes to temperature, and precipitation amount and timing. Our approach resulted in highly accurate classifications of wetlands of varying size and ephemerality. We found that wetland ephemerality was best predicted by precipitation in the form of snow. Lastly, we observed an increase in highly ephemeral and ephemeral wetlands compared to current conditions under climate change. These results have important implications for wetland biodiversity and genetic connectivity of wetland-dependent species, such as amphibians, that require a network of wetlands for dispersal.

A MULTI-METHOD ANALYSIS OF RANCHER ATTITUDES TOWARD ENDANGERED SPECIES CONSERVATION IN THE SOUTHWESTERN UNITED STATES.

Aaron M. Lien*, George B. Ruyle, Laura López-Hoffman

University of Arizona, Tucson, AZ

In March 2014, the United States Fish and Wildlife Service (USFWS) designated “critical habitat” for jaguars (*panthera onca*) in southeastern Arizona and southwestern New Mexico. Critical habitat is a legal designation under the Endangered Species Act. Federal agencies are required to conduct additional consultation with the USFWS before conducting or funding any project within the designated geographic critical habitat area in order to prevent adverse modification or destruction of habitat critical to the survival of an endangered species. The primary land use in the area designated as critical habitat for jaguars is ranching. Most ranchers in this region rely on a combination of private and public lands for grazing, with federal grazing permits making up the majority of many ranches. During the public comment phase of the critical habitat rulemaking process, some ranchers expressed concerns that the designation of critical habitat could limit or end public lands grazing. We conducted a multi-method study to understand the attitudes of ranchers in the region toward the jaguar critical habitat designation, endangered species regulations generally, and incentive-based approaches to endangered species management in the region. Data was developed through in-depth interviews, a written survey, and extension workshops that included focus groups. We found participants in our study are more

concerned about how new endangered species regulations may impact their operations than they are about depredation impacts from increased jaguar presence; many of the participants are interested in incentive-based conservation approaches, depending on regulatory assurances and funding sources; and an overall commitment to wildlife conservation and range management. We will present the results of our study and discuss implications for endangered species management on public and private lands.

THE LAND ETHIC AS A CORE VALUE OF THE SOUTHERN ARIZONA RANCHING COMMUNITY: A Q-METHODOLOGY STUDY.

Aaron M. Lien*, George B. Ruyle, Laura López-Hoffman

University of Arizona, Tucson, AZ

It is easy to think of ranchers as a single community with similar opinions and viewpoints. In reality, ranchers are a diverse group of individuals with a range of viewpoints on issues such as the role of government in range management, conservation, wildlife management, and motivations for ranching. By understanding this range of perspectives, it is possible to develop more responsive research, extension, and policy. Using Q-methodology, a technique borrowed from psychology, we've developed a new understanding of the range of opinions about conservation and range management in the ranching community in southeastern Arizona and southwestern New Mexico. Q-methodology, though not new technique, is new in its application to a range management context. Through factor analysis, Q-methodology provides a quantitative means of evaluating what is normally treated as qualitative data – statements by ranchers about their views on ranching. In applying Q-methodology in southeastern Arizona and southwestern New Mexico, we've identified several perspectives on the relationship between ranching and conservation, the role of government, and the business of ranching. We are using these perspectives to inform a larger body of research into innovative incentive programs for the conservation of endangered species. We will review Q-methodology, how our study was conducted, analysis and results, and discuss the challenges and potential for using Q-methodology in range management research and extension.

DISTRIBUTION AND CONNECTIVITY OF GREATER SAGE-GROUSE IN A MULTIPLE-USE LANDSCAPE.

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In the intermountain west, two important components of land management are energy development and Greater Sage-Grouse conservation. Greater Sage-Grouse has experienced a reduction in its distribution and population decline in association with land-use conversion. Sage-grouse are closely tied to sagebrush habitat; development within this habitat is known to negatively influence lek (breeding site) occupancy and gene flow (connectivity) across the landscape. Our goal is to understand how land-use influences distribution and functional connectivity of leks in the Powder River and Bighorn basins in Northern Wyoming. We implemented a stratified random sampling design to capture variation in development and habitat fragmentation across the study area. We developed a map of lek distribution using 460 leks from Wyoming Game and Fish department sage-grouse database, 81 pseudo-absences,

and important environmental and land-use characteristics. To assess connectivity, we collected DNA samples (i.e., shed feathers) from 91 sites and estimated genetic distance. We present and compare the lek distribution map and functional connectivity model based on relating 2012 - 2014 field data to limiting factors across the landscape: percent sagebrush, development, road density, and topographic relief. Lek distribution is negatively related to development; both amount and configuration of development surrounding leks decreases probability of lek occurrence. Connectivity of sage-grouse leks is positively associated with undisturbed areas of contiguous sagebrush habitat. By assessing these models we can hypothesize if patches of remaining sagebrush that may not be optimum for leks are important for continued connectivity. These models will be the basis for predicting potential changes in lek occurrence and functional connectivity in the face of different scenarios of landscape change. Our research will provide a scientifically-based decision-making tool for prioritizing development, protection, and restoration that will drive stakeholders to work together for a successful outcome.

LINKING SEED BANK COMPOSITION AND SPATIAL VARIATION IN VEGETATION TO PIPELINE DISTURBANCE IN MIXEDGRASS PRAIRIE.

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Disturbances such as pipelines, roads and well sites can function as corridors for seed dispersal and allow invasive species to establish. Over-time introduced or ruderal species may saturate the seed bank near the disturbance and eventually migrate into adjacent native grassland. Invasive species of potential concern in the mixedgrass prairie include cool-season grasses (*Agropyron cristatum*, *Poa pratensis*), noxious weeds (e.g. *Sonchus arvensis*) and escaped agronomics (*Melilotus* spp.). All these species can be highly competitive and alter their microenvironment, thereby facilitating further invasion and displacement of native plant species. We hypothesized that the presence and abundance of invasive plants, both above-ground and in the seed bank, will increase as a function of spatial distance from disturbance and time since pipeline construction. Pipelines were visually identified and sampled along transects oriented perpendicular to the pipeline at 15 varying distances. Spatial sampling intensity was high adjacent to the pipeline and decreased out to a distance of 55 m. Within each distance, 16 soil cores (3.25 cm wide x 6 cm deep) were removed and bulked, then placed in a greenhouse where emergent seedlings were identified and counted. In addition, cover of above-ground vegetation was assessed at every third transect. By comparing seed bank and vegetation composition we will identify the degree of similarity between the seed bank and current plant community, and evaluate how this relationship changes with distance from pipeline and age of the disturbance. Records of pipeline installation and reclamation may also identify practices that promote the conservation of native vegetation and minimize invasive species.

DISCONNECT BETWEEN WHITE-TAILED DEER DENSITY AND FORAGE RESOURCES IN SOUTHERN TEXAS RANGELANDS.

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Management of white-tailed deer (*Odocoileus virginianus*) populations has traditionally been based on a density-dependent model of population growth in which deer morphology and demography vary with deer density. Density-dependence appears to operate through declines in diet quality as a result of foraging induced changes in the vegetation. This population model is based on research conducted in forested regions of the United States. The model may not apply to white-tailed deer inhabiting the semiarid, shrub-dominated rangelands of southern Texas. In a 9-year study of enclosed deer populations managed at densities ranging from 12 – 50 deer/km2, birth rates, survival rates, population growth rates, fawn and yearling growth rates, and antler size did not vary with deer density. Furthermore, a high-quality pelleted supplement improved every morphological and population parameter measured, demonstrating that nutrition limits deer populations in this region. The apparent contradiction of weak density dependence in populations that are nutritionally limited is explained by characteristics of the forage resources. South Texas rangelands have a high biomass of browse that is moderate in nutritional quality. Shrubs are a vast food resource that is sufficient for maintenance of adult deer but not for production. Furthermore, shrubs have chemical, physical, and structural attributes that limit the impact of large herbivore foraging, thus enabling persistence over a wide range of deer densities. Precipitation in this semiarid environment causes a flush of herbaceous vegetation which provides the high-quality forage necessary for reproduction. Deer persist in this environment because high adult survival bridges periods of poor reproduction caused by low precipitation. Implications of these findings for deer management in southern Texas are that managers may have more flexibility than previously thought in managing deer densities, that high adult survival is critical to sustain populations, and that management actions to improve diet quality should increase productivity of deer populations.

INDUSTRIALIZATION OF NORTH AMERICAN RANGELANDS: IMPLICATIONS FOR CONSERVATION IN PROTECTED AREAS.

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Oil and gas has traditionally had spatially limited impacts in terrestrial systems, but new technologies are enabling unprecedented scales of development across large areas of North American rangelands, with unknown impacts for grassland biodiversity. Protected areas are considered by the conservation community to be one of the most effective means of mitigating for biodiversity loss. However, novel patterns and scales of oil and gas development represent the potential for new anthropogenic impacts to diminish their effectiveness. Our study identifies the extent of oil and gas development within protected areas and in the matrix in which they are embedded. We use proprietary and publicly available oil and gas datasets to establish the amount of oil and gas wells within protected areas in North America, and quantify the extent and magnitude of oil and gas development in the matrix surrounding protected areas. More than 25,000 wells were drilled in protected areas between 1900 and 2012, with the number of new oil and gas wells increasing over time. Increased development within protected areas is largely restricted to those established for sustainable resource use. However, high

numbers of wells are found in proximity to all categories of protected areas. This development of the matrix surrounding conservation lands could have long lasting impacts on the ecosystem dynamics within these areas, as a formerly connected network of protected patches is transformed into isolated islands in an industrialized matrix. If protected areas are to continue to effectively conserve biodiversity, a multi-scale assessment of the effects of oil and gas development is necessary to advance conservation planning from local scales to biome levels. This provides an opportunity for rangeland ecologist to work with industry on land-use planning and restoration to avoid future loss of biodiversity in the face of large-scale conversions of rangelands.

PLANTING DESIRABLE GRASSES TO OUTCOMPETE MEDUSAHEAD.

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Rangeland managers in the west are challenged with trying to control medusahead (*Elymus caput-medusae*). Medusahead is found in virtually every county in California and has been spreading rapidly. Research continues to attempt to find long term solutions that are economically viable for ranchers to utilize. Many prior efforts have demonstrated that seeding of perennial grasses can potentially outcompete medusahead. In this trial we planted a variety of native perennial, introduced perennial, and introduced annual grasses on the foothill annual rangeland and intermountain rangelands. In the first year of the trial we established site locations, applied weed control, and seeded six different grasses using either a no-till drill or by broadcast and harrowing seed. Preplant weed control was very successful at most sites, with the cover of medusahead at all sites combined ranging from 2-3% in the treated areas and 27% and higher in the control areas. All sites harrowed, including the two intermountain sites, provided less than satisfactory stands. All drilled plots looked very promising in having an opportunity for successful establishment. In year 3 we seeded an annual clover mix containing subterranean clover, vetch, and rose clover into all of the sites that we considered successful in initially establishing the previous year. We will continue to evaluate these plantings in the upcoming growing seasons and include grazing to evaluate their ability to survive under normal management scenarios. Our data to date looks like seeding can be a viable option for ranchers and land managers to consider. We will also present a cost analysis of the different species we planted.

A RANCHERS PERSPECTIVE ON VGS.

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I am a rancher in Gila County Arizona and have been monitoring vegetation on our ranch for 8 years. For the past 4 years we have utilized the VGS data system and have come to realize the great value in

the system. Prior to using VGS we were forced to use paper and pencil to document collected data. This was a tedious and time consuming process and did not afford us the opportunity to quickly analyze and compare the data we were collecting. Often, while we are on the Key Area we are monitoring we take note of previous and present rainfall data, and we now have the ability to correlate past production, species composition, frequency, and ground cover to the timing and amount of rainfall. VGS gives us the ability to examine 8 years of data from varied perspectives. We can now track trends and changes in our vegetation. We can compare pastures regarding the variety of species, production, and ground cover. We can now merge past utilization data with the management of our cow herd rotational grazing schedule and quickly determine the carrying capacity for each pasture based on past data. Our ranch is on National Forest land and we monitor frequently with US Forest Service staff. VGS provides us with the capability to discuss grazing strategies and schedules while on the range with those land managers. Recent additions to VGS have upgraded an already excellent software program. One problem all ranchers have while monitoring is plant identification. We now have the capability to access an extensive plant data base with full color photographs of each species. In summary my profession as a rancher has been changed dramatically for the better because I can now make better plans and better monitor my ranch management.

LITTER AND DEFOLIATION EFFECTS ON THE POPULATION DYNAMICS OF CONTRASTING LEGUMES SEEDED INTO GRASSLANDS OF THE PARKLAND AND MIXEDGRASS PRAIRIE.

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Legumes vary widely in their value for forage production, and can also be invasive within native grasslands. Long-term retention or exclusion of legumes in grasslands requires information on the inherent demography of various species, particularly as legumes may vary widely in their tolerance of defoliation and environmental conditions. In theory, microsite availability for legume recruitment could be manipulated through management; for example, grazing can alter competing vegetation and litter covering the soil, in-turn modifying light intensity, soil moisture and soil temperature. We designed a demography study that tracked seedling emergence, survival and persistence of individual seeds from 6 legume species in 4 microsites under divergent treatments that reflected contrasting management conditions. Microsite conditions were altered by either 1) removing litter, 2) defoliating live biomass at peak growth (to simulate grazing), 3) both removing litter and defoliating, or 4) were left untreated. Legumes tested included 2 tame forage species [white clover (*Trifolium repens*) and alfalfa (*Medicago sativa*)], 2 invasive legumes [Cicer milkvetch (*Astragalus cicer*) and sweet clover (*Melilotus officinalis*)], and 2 native species [purple prairie clover (*Dalea purpurea*) and American vetchling (*Vicia americana*)]. Legumes were planted in lots of 40 seeds within 40 x 40 cm plots under all treatments (4 reps of each) in both native and tame grasslands at each of two locations (Aspen Parkland and Mixedgrass Prairie) during mid-May of 2014. Within each plot, each seed (N= 15,360 total) was glued to a toothpick and inserted to a 1 mm depth in a systematic grid for repeated assessment. The fate of individual seeds was subsequently monitored throughout the growing season until recruitment halted after the first killing frost. Results of this study will provide information on the relative recruitment of different legumes in response to regional environment, competing vegetation identity, disturbance and growing conditions,

and thereby highlight opportunities to promote (beneficial forages) or impede (invasive) legumes, depending on management objectives.

CONNECTING LONG-TERM MONITORING DATA FROM VEGETATION PLOTS AND REMOTE SENSING IN THE SOUTHWESTERN USA.

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Understanding vegetation response to changing climate patterns is an important element of rangeland management and supports the use and development of ecological site descriptions. Monitoring of rangeland conditions with remote sensing can be misleading if ground measurements are not used to interpret changes in vegetation indices. We used a 25 year time series of Landsat normalized difference vegetation index (NDVI) to evaluate vegetation dynamics in the Malpai Borderlands Area of Arizona and New Mexico (~324,000 ha). The NDVI time series was decomposed into trend and seasonal variability to better understand spatial and temporal changes in vegetation dynamics across the region. Long-term vegetation monitoring plots and soil profile descriptions provided ground-based information to interpret patterns of NDVI. Monthly PRISM climate data were also used to interpret NDVI and vegetation dynamics. We compared changes in percent cover of plant functional types on a five year interval to the decomposed time series between measurements to elucidate causes of NDVI variability. Management practices across the time period are largely unknown; hence our interpretations reflect variable climate patterns and the effect of fires in the region. Preliminary results indicate a decrease in perennial grass cover in 2003 following a period of extreme regional drought. Perennial grass cover at most plots rebounded to pre-drought conditions or more perennial grass cover by 2008; however, some did not. We will present a detailed analysis of NDVI trends across the region and directly link changes in measured cover at monitoring locations to changes in NDVI and precipitation. Connecting NDVI time series data to point locations of measured cover values will advance interpretations of remotely sensed imagery for broad-scale assessments of rangeland condition and facilitate improved ecological site interpretation.

SCIENTIFIC AND MANAGEMENT KNOWLEDGE IN COMPLEX SYSTEMS.

Grady Grissom*

Rancho Largo Cattle Co., Fowler, CO

Complex systems exhibit inconsistent variable relationships that give rise to threshold behavior. Thresholds have been evaluated extensively in relation to state and transition boundaries, but are not commonly evaluated within states. Linear or curvilinear graphical trends inflect sharply at thresholds. Thresholds are targets for management to attain or avoid since a small variation of a management variable can give large response of the dependent variable at thresholds. Extrapolation of empirical results across a threshold can drive controversy. Threshold behavior may help explain the rotational grazing controversy. The relationship between grazing recovery period and plant diversity (over years of grazing) may display threshold behavior in some settings. Initial seral state and scale may also be

threshold variables in grazing trials. Managers are forced to make tens to hundreds of decisions (trials) per month in adaptive grazing systems with multiple paddocks. The large number of uncontrolled trials over time can lead management to recognize threshold relationships in complex biological systems. In contrast, the small number of trials at high expense available in controlled scientific studies provides limited ability to find thresholds. Science knowledge is especially limited when trials are set up to answer a yes/no question such as, "is one grazing protocol statistically different than another". Induction driven management knowledge from a few individuals has very limited value to range science. However, uncontrolled management knowledge may have significant value if tested over time by hundreds or thousands of managers. Over time production managers sample management knowledge and utilize methods that give results. In a competitive environment they cannot (and will not) commit time and capital resources to ineffective management tools. Effective communication between management and science requires that science value time-tested management knowledge. Management knowledge can provide hypothesis for controlled experiments that evaluate a wide range of variable values

ASSESSMENT OF LAND RESOURCE UNITS (LRU'S) IN CALIFORNIA'S SIERRA NEVADA FOOTHILLS USING VEGETATION COVER DATA.

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Developers of Ecological Site Descriptions (ESD's) increasingly rely on moderate-scale ecoregion designations known as the Land Resource Unit (LRU) to resolve differences in vegetation communities (e.g. species composition, biomass production) that arise from localized climatic effects. Hierarchically, the LRU is nested within the Major Land Resource Area (MLRA) and specifies ranges for a specific climatic zone that can accommodate a suite of similar ESD's from a management perspective. The implications of LRU development can be monumental; if developed with robust criteria, LRU's may inform land owners, managers, and other interested entities in areas such as range management plans, wildlife habitat restoration, forestry, and recreation. The Sierra Nevada Foothills (MLRA 18) has been heavily utilized for a wide variety of resources over past centuries and today is recognized for its cultural resource hotspots, a gateway to several National Parks within the Sierra Nevada Mountains, and large expanses are dedicated to livestock production. Our study area, consisting of mostly privately owned landholdings, is centrally located within the Sierra Nevada Foothills MLRA and overlaps sections of two distinct zones identified in a previous ecoregion delineation project (EPA, Level IV). Our objective is to identify the main abiotic drivers of vegetation patterns across the two zones in order to improve an ongoing soil survey. Using EPA Ecoregion polygons as our spatial extent, we will employ vegetation cover data collected from 2009 to 2015 to evaluate soils, topographic, and climatic data. Specifically, we will use the vegan package in *R* to identify groupings of major vegetation communities based on environmental gradients. We will then use non-metric multidimensional scaling to compare the major groupings via dissimilarity indices. The results we present are specific to the Tuolumne-Calaveras County soil survey, but our techniques may apply to modeling LRU's of the entire MLRA.

INTRODUCTION TO THE VEGETATION GIS DATA SYSTEM (VGS).

Del Despain*[1], Douglas R. Tolleson[2]

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The Vegetation GIS Data System (VGS) is a free software application for recording and managing vegetation and other ecosystem or environmental sampling data. The application provides: 1) A data repository for organizing and managing data, photos, documents, positional coordinates and other information associated with an unlimited number of study sites or locations. 2) Electronic tools for recording data in the field (using tablet PCs) as well as historical data in the office. 3) Reports and tools for summary and presentation of results in the field or office. VGS meets the needs of both field personnel and administrative level managers. One reason for the success of VGS is that both office and field data entry forms are designed to fit specific combinations of sampling methods and forms in an efficient manner for a particular sampling protocol. The VGS software has been adopted for use by various government, university and private entities. It is widely used for vegetation inventories and monitoring, but is equally suited to a variety of ecosystem and environmental data requirements. Users can generate forms for recording data for their own protocols by specifying the combination and order of data entry modules that appear on the forms in either a single or multi-form format. Each data entry module automatically displays the appropriate input panel (species, categories, classes, numeric keypad, etc.) when the module is selected for input. In general, the entire screen is dedicated to one point, quadrat or other sampling unit at a time which greatly reduces input errors and user fatigue. We can develop and add data entry modules to support protocols where existing modules do not meet requirements. For vegetation data, VGS implements the USDA PLANTS Database for species input, but smaller template lists may be created by the user for species and categories.

RESTORING NATIVE VEGETATION IN LANDSCAPES INVADED BY EXOTICS.

John Reilley*

USDA/NRCS, Kingsville, TX

South Texas is no stranger to exotics. We have been dealing with them from as early as 1915. We have come to focus our understanding on the mechanisms for their invasion which has lead us to the details necessary for restoring native vegetation. What has become known as the “South Texas Natives “approach, is the development of an ecologically based strategy and tools for restoring native vegetation in south Texas. We will cover everything from the critical concerns of land use history and site attributes to the seedbed preparation. We will discuss at length the development of the seed mix we use for a successful restoration. For it is the development of the appropriate seed mix that makes our approach unique. We like every mix to contain 8-12 different species with half of those species being early successional. The mix should have perennial grasses along with some forbs and legumes. And most importantly, every species we use is a south Texas ecotype that has been tested, selected and commercialized because of its adaptation to South Texas conditions. It is with this approach that we have had over a 70% success rate in restoring native vegetation on exotic invaded landscapes.

INVASIVE PLANT SPECIES AND NOVEL RANGELAND ECOSYSTEMS.

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Rangelands represent the dominant land use systems in many countries of the world and provide sociological and cultural benefits to millions of people in both rural and urban areas. The undesirable impacts of rangeland weeds have been recognized for well over 100 years and infest between 41 and 51 million ha of public and private land. Invasive plant management has often focused on control of single species without regard to the unintended consequences of the control method. A more appropriate approach to invasive plant management is to evaluate the ecological mechanisms and processes that favor their success and develop management strategies that promote maximum functionality, ecosystem services, and resilience to reinvasion. Global trends suggest that many, if not most, ecosystems are novel and have an altered structure and function with new combinations of species. The challenge for land managers in the future will be to determine what degrees or types of changes are considered beneficial, while avoiding actions that create bigger problems and further ecosystem degradation. Given this high level of uncertainty, we sought to identify some of the major conceptual advances in invasive species management that have occurred during the past 25 years and explore way to proactively apply them to rangelands that fall under the umbrella of novel ecosystems.

RANGELAND MONITORING WITH VGS: USFS PERSPECTIVE.

Judith Dyess*[1], Douglas R. Tolleson[2]

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Collaborative range monitoring on USFS lands between forest personnel, permittees, and personnel from other interested parties such as extension or sister agencies facilitates sustainable resource management. In Region III of the USFS, we have partnered with the University of Arizona to develop and promote rangeland monitoring techniques for over 20 years. Since 2008, we have worked with Dr Del Despain to field test his VGS – tablet computer system for collection, summarization, and presentation of monitoring data. This practical field tool expedites both pre-collection preparation and post-collection data summarization for USFS range managers. Actual field data collection time is similar to methods using traditional paper forms, but user fatigue and accuracy of data entry has been improved by using VGS. We have tested the system in a variety of ecosystems and with several field techniques. VGS has been used to inform typical range trend studies using methods such as ecological ground cover and pace-frequency transects, post-fire canopy cover using line intercept, and brush density using belt transects. The ability to see previous data collected from a given site and view it along with data just recorded while in the field facilitates discussions among forest resource managers and multiple users. These discussions can improve rangeland resource management.

USING VGS TO INTERPRET AND APPLY LONG-TERM MONITORING DATA: BLM PERSPECTIVE.

Whit Bunting*[1], Douglas R. Tolleson[2]

[1]BLM, St George, UT, [2]University of Arizona, Tucson, AZ

We have used Dr Del Despain's VGS software with ruggedized tablet computers for a number of years on the Arizona Strip District of the BLM as part of the Cooperative Range Monitoring Project with the University of Arizona. The Arizona Strip is a large, remote, and expansive landscape in northern Arizona above the Grand Canyon, east of Las Vegas. From a practical standpoint, we need data collection tools that will stand up to a wide range of weather extremes and that we can depend on once we leave the office to go to the field. The VGS system is user friendly and most of the tablet computers have held up well in the field under our conditions. But the aspect of using this data collection system that I want to discuss is that of allowing us to input, summarize, and apply many years of range monitoring data we had collected prior to development of the software. In the cooperative project between the university and BLM, project personnel have input existing range monitoring data into VGS so that we now have this historical data at our fingertips in the office or the field. Similar to the experience that the USFS or NRCS has with VGS, we feel that this ability enhances our discussions with permittees. We are now able to more easily and efficiently compare range monitoring data with other important information such as actual use or precipitation.

RANGELAND HEALTH AND ECOLOGICAL SITE DESCRIPTIONS: NEW OPPORTUNITIES.

Jeffrey Herrick*

USDA-ARS, Las Cruces, NM

This presentation will review how ecological site descriptions (ESDs) are used to support rangeland health evaluations, and how rangeland health evaluations can be used to improve interpretations based on state and transition models (STMs). Reference sheets that serve as the standard for evaluating rangeland health using the "Interpreting Indicators of Rangeland Health" protocol are now included in United States ESDs. Other information included in the ESDs used to support development of the reference sheets includes the STMs: the natural range of variability within the reference state serves as the reference for each indicator. Defining this range of variability requires knowledge about the natural disturbance regime, production, and soils, which is also included in the ESD. Rangeland health evaluations can improve STM-based interpretations by helping to identify ecological processes have been modified, resulting in a change in resilience. This information can be used to help identify appropriate management interventions. The presentation will conclude with a brief discussion of some new mobile apps that will make it easier to identify the correct ESD to be used for rangeland health evaluations, and to provide feedback on STMs and rangeland health reference sheets. The global "Land-Potential Knowledge System (LandPKS) allows users to use their phone quickly determine the climate for their location, and to help identify which soil, and therefore which ecological site they are on.

STOCKING RATE DECISIONS AND THE INVASION OF BROOM SNAKEWEED (GUTIERREZIA SAROTHRAE).

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Overgrazing is considered to be a key driver of undesired transition by the definition of rangeland State and Transition Models (STMs). Conceptually, the probability of moving to a less desirable state or community phase (i.e., Easily-reversible variants of states) increases with increased grazing pressure. Yet, how these probabilities change with the level of grazing is rarely known or estimated. Three blue grama (*Bouteloua gracilis*) study sites located on the Plains of Eastern New Mexico were monitored for 35 years, providing the data required to estimate the probability of broom snakeweed transition to different levels of infestation (None/Light, Moderate, Heavy). A stochastic Monte Carlo simulation model was developed which incorporates site-specific weather variability and stochastic events to estimate the net present value of income, considering the lease value of forage. Broom snakeweed, a short-lived perennial woody shrub, can quickly invade when environmental conditions are favorable and die out with drought. Using the long-term monitoring data and logistic regression it was determined that the probability of snakeweed invasion increased with higher April temperatures, with increased rainfall during the second quarter, and when a heavy stand of the invasive weed was present the previous fall. Further, as the amount of herbaceous grass material increased the probability of snakeweed infestation decreased. Recognizing that grazing reduces year-end herbaceous standing crop, snakeweed transition probabilities at various stocking rates were computed. If a successful snakeweed control treatment moved the weed infestation level to the None/Light category, treatment life was estimated to be 3.2 years with a 50% grazing use level, 4.1 years at 35% use, and 5.1 years with a conservative 20% use. Thus, light grazing was environmentally beneficial, but there was a tradeoff with economic returns. The estimated discounted net present value was $42, $71, and $96 for the 20%, 35% and 50% use rates, respectively.

FORAGE PRODUCTION AND CATTLE PERFORMANCE OF STEERS GRAZING FERTILIZED SMOOTH BROMEGRASS AND SMOOTH BROMEGRASS-LEGUME PASTURES.

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A 7.3 ha study site at the Agricultural Research and Development Center near Mead, NE was used to compare forage and animal production between fertilized smooth bromegrass pasture and smooth bromegrass-legume pasture. The site was divided into six pastures, with three smooth bromegrass and three smooth bromegrass-legume (alfalfa, red clover, and birdsfoot trefoil) treatments being randomly assigned to the pastures. Each pasture was subdivided into paddocks to allow for rotation through the pasture, and groups of 3-4 steers were rotationally grazed within each pasture from early May to early October in 2012, 2013, and 2014, except that steers were removed early in 2012 because of drought. Steers were weighed at the beginning and end of the study, and at regular intervals during the grazing season. Five exclosures (1 m2) were placed in each paddock prior to the initiation of grazing each year. The vegetation in the exclosures was clipped at ground level in mid-June and late September to estimate forage production each year. Vegetation was also clipped at ground level in 10 quadrats (0.25 m2)

within each paddock immediately before each grazing period to allow assessment of forage availability. Overall, there was no difference in weight gains between the two pasture types, but the smooth bromegrass-legume pastures provided greater grazing days than the fertilized smooth bromegrass pastures. Forage availability was often higher in the fertilized smooth bromegrass pastures during the time between fertilizer application and seed production, but was often higher in the smooth bromegrass-legume pastures after the smooth bromegrass finished seed production.

STRATEGIC RANGELAND NITROGEN RERTILIZATION FOR MEDUSAHEAD MANAGEMENT.

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We evaluated the effects of nitrogen (N) fertilization on species composition of grazed annual rangeland in Northern California. Treatments included rates of 0, 30 (low) and 60 (high) pounds of actual N per acre, in the form of ammonium sulfate, combined with seasonal timings of fall and early spring applications in year 1 and 0, 30 and 60 pounds N per acre in year 2. Treatments were applied during the 2012/2013 and 2013/2014 growing seasons at three different locations and then monitored the spring of 2015. Each experimental site was grazed, though small differences in grazing strategy existed. Analyzed with all three sites combined, the two consecutive years of early-spring applications at 60 pounds N, combined with grazing, reduced medusahead (*Taeniatherum caput-medusae)* basal cover from 23 to 6% (P=0.01). No significant difference in medusahead existed between any other fertilizer treatments, although the year 1 + year 2 N applications resulted in lower medusahead cover of 10% compared to the application in year 1 only of 16% (P=0.006). The average of all low and all high N applications lowered medusahead cover from 14% and 13%, respectively, from 23% with zero N applied (P=0.02), indicating that on average the lower rate can provide some benefit in reducing a medusahead population. Interestingly, fertilizer treatments did not have significant effects on basal cover of any other grass and forb species, only on medusahead. A strategy of enticing cattle to graze medusahead patches through N fertilization may help reduce small medusahead infestations, and further studies would be needed to determine limits to the proportional area of a field that should fertilized to sustain a negative impact on medusahead.

POST-FIRE SEED PRODUCTION OF MOUNTAIN BIG SAGEBRUSH.

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Fire is the dominant disturbance in big sagebrush ecosystems. Of the three subspecies of big sagebrush (*Artemisia tridentata),* mountain big sagebrush (ssp. *vaseyana*; MBS) is the most resilient to disturbance, but still requires favorable climactic conditions and a viable post-fire seedbank for rapid recovery. We used data from 13 central Utah burn sites and a space-for-time substitution strategy to identify trends in

seed production during post-fire recovery. We hypothesized that seed rain (mean seeds produced/ m2) would be maximized before stands reached equilibrium due to higher individual plant fecundity and relatively low levels of intraspecific competition. Using estimates of population density and individual plant fecundity, we estimated potential seed rain for three size classes of MBS and used forward stepwise regression analysis to identify significant factors influencing seed production over time. Density for small (basal stem diameter (BSD) < 1 cm) and medium-sized (BSD = 1-3 cm) plants was consistently low and was not affected by time since fire, while large plant (BSD > 3 cm) density steadily increased (p=0.0062), suggesting continual recruitment over time. Fecundity for all size classes was significantly correlated with previous winter or spring precipitation (p range =0.0006-0.0154). Large plant fecundity dominated reproductive output and decreased as total plant density increased (p=0.0133). Seed rain increased with total MBS cover (p=0.0028) suggesting that losses in individual plant fecundity were more than compensated by higher densities of seed-producing plants. Total MBS cover and seed rain appeared to level off between 20 and 30 years after fire even though stand structural characteristics may not have fully stabilized. Results partially support our hypothesis that the time required to reach MBS seed rain maximum was not tightly bound to indicators of stand maturation. Understanding the factors that influence post-fire seed production can help land managers better manage for successful recovery.

SEASONAL SELECTION OF CRP AND NATIVE SHINNERY OAK HABITAT BY LESSER PRAIRIE-CHICKENS IN NEW MEXICO.

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The lesser prairie-chicken (*Typanuchus pallidicinctus*) is a species of conservation concern across its current range. Research in the northern portion of its range has shown that Conservation Reserve Program (CRP) grasslands are used by lesser prairie-chickens for breeding, nesting, and brood rearing. Use of CRP grasslands by lesser prairie-chickens in the southern portion of their range, specifically in New Mexico, has not been well documented and there is disagreement as to its importance seasonally. Our research objectives were to determine if, when, and for what purpose lesser prairie-chickens use CRP habitat in eastern New Mexico. We captured lesser prairie-chickens in the spring of 2014 and 2015 on leks to monitor their movements throughout the breeding and non-breeding seasons in relation to CRP, native shinnery oak (*Quercus havardii*), agricultural, and mesquite dominated (*Prosopis glandulosa*) habitats. Lesser prairie-chickens almost exclusively used either shinnery oak or CRP habitats. Interestingly, lesser prairie-chickens used CRP habitats in much lower proportion to their availability and used native shinnery oak dominated habitats in much higher proportion to their availability during the breeding season. During the non-breeding season, however, CRP habitats were used in closer proportion to their availability. Overall, this study reveals that CRP habitats are used by lesser prairie-chickens to a much lesser degree than native shinnery oak habitats in New Mexico and habitat improvement efforts designed to benefit this species in eastern New Mexico should focus on conservation and restoration of native shinnery oak.

ECOLOGICAL SITES FOR THE INFORMATION AGE.

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The paradigm of ecological sites (ESs) as a land classification system has evolved over several decades. The current definition of ESs contains robust concepts that make the ES system uniquely suited for state-and-transition models (STMs) that depict ecological change over time. The ES development effort has gained significant support in recent years. The Natural Resources Conservation Service announced accelerated ES development in 2010, including jobs for ES specialists and formal support from the U.S. Forest Service and the Bureau of Land Management. In 2013 the Interagency ES Handbook for Rangelands was released to dozens of newly-hired ES specialists across the country. National and regional ES leadership is now established, and an effort to produce provisional ESs for the entire continental U.S. by 2020 is underway. In light of the current momentum for ES development, we introduce several concepts which are key to the sustained relevance of ESs in the Information Age. We suggest a slight adjustment to the apparent ES paradigm, from “management tool” to “reference library” of ecological observations, organized according to ES classification and STM. The implications of the paradigm shift are discussed in relation to the ES definition and ES development efforts. We contend that an ES reference library paradigm is highly compatible with the expectations of contemporary information consumers as well as potential ES collaborators. Furthermore, the manner in which ES information is captured, organized, and delivered must be modernized to meet user expectations and remain relevant in the long-term. Examples of improved information capture, organization and delivery are offered, including interactive ES identification keys, integration of ecological interpretations (e.g. soil health, wildlife, etc.) into one-page interactive STMs, information feedback mechanisms from ES users and contributors, etc. This talk is intended to generate meaningful discussion and collaboration for the long-term relevance of ESs.

GEOGRAPHIC VARIATION IN THE MORPHOLOGY OF WHITE-TAILED DEER IN SOUTH TEXAS.

Kory R. Gann*[1], David G. Hewitt[2], Michaela Rice[3], Alfonso Ortega-S. Jr.[4], Randy DeYoung[3], J. ALFONSO ORTEGA-S.[2], Timothy E. Fulbright[3], Thomas W. Boutton[5], Tyler A. Campbell[4]

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To assess the relationship between soil physical properties and deer morphology, we captured 2,775 white-tailed deer in autumn 2011–2014 on 4 East Foundation properties that range in location from the Gulf Coast to 90 miles inland. We determined the percent of each capture area composed of soils with a surface texture classified as sandy loam or clay loam, as well as the percent of each capture area composed of soils with an average percent sand >70% and >80% at a depth of 0−24 in. Percent of each capture area composed of soils with > 80% sand best explained differences in deer morphology. For every 1% increase in the proportion of the capture area composed of soils with >80% sand, female body

weight decreased by 0.29 lbs. for 2−3 year olds, 0.35 lbs. for 4−5 year olds, and 0.39 lbs. for the 6+ age class ($P < 0.01$, R2 = 0.735). The male body weight model predicted that for every 1% increase in the proportion of the capture area composed of soils with >80% sand, male body weight decreased by 0.71 lbs. for 2−3 year olds, 1.13 lbs. for 4−5 year olds, and 1.03 lbs. for the 6+ age class ($P < 0.01$, R2 = 0.853). For every 1% increase in the proportion of the capture area composed of soils with >80% sand, antler measurements (Gross Boone and Crockett score) decreased by 0.45 points for 2−3 year olds, 0.68 points for 4−5 year olds, and 0.42 points for the 6+ age class ($P < 0.01$, R2 = 0.775). The soil parameter had no effect on body weight of fawns or yearling (1 year old) deer of either sex or antler size of yearling males. The efficiency of deer management programs may be reduced on sites with sandy soils by increasing the amount of time necessary to achieve desired results or by limiting the overall results of the management program.

SOIL MOISTURE AND GROUNDWATER DYNAMICS IN WESTERN JUNIPER WOODLANDS.

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The significant expansion of juniper (*Juniperus* spp.) during the last two centuries has disrupted important ecological functions and hydrologic processes occurring in many watersheds throughout the western U.S. Our long-term research study in central Oregon has provided critical information regarding vegetation and hydrology interactions in winter precipitation-dominated watersheds. This paired-watershed study comprises an area of approximately 500 acres and includes one treated (~ 90% juniper removal) and one untreated watershed. The wet season in the study area occurs between September and April, with the majority of the precipitation occurring as snowfall. The study site has been instrumented to record different hydrologic parameters including soil moisture, runoff, and groundwater. Also, different field campaigns have been conducted to assess vegetation features such as canopy cover and species frequency. In general, greater soil moisture content and an increase in shallow groundwater residence time was observed in the watershed where juniper tree density had been reduced. Results from an intensive monitoring campaign (2014-2015) of top soil moisture showed there was a significant, although relatively small, difference in soil moisture content in treated vs untreated watersheds. Also, vegetation data collected showed that canopy cover significantly affected soil moisture levels across dry and wet seasons. Perennial grass cover was positively correlated with changes in soil moisture, whereas juniper cover was negatively correlated with soil moisture content. Shallow groundwater recharge during the winter season showed a 4 to 6 week delayed response in wells located in a downstream valley when compared to upland well locations. An isotope trace analysis showed similar signature for upland and valley well locations, indicating there are temporary hydrologic connections through the groundwater system. Study results provide valuable information towards understanding ecohydrologic features of woody vegetation expansion in semiarid areas in the West.

A GRAZING FRONTIER: FROM GRAZING MANAGEMENT TO TARGETED GRAZING

Karen L. Launchbaugh*[1], John W. Walker[2]

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The skills and knowledge of grazing management were initially designed to manage the impacts of grazing and improve the efficient conversion of plant biomass into livestock products. Generations of herders and scientists have focused their efforts on improving the production efficiency of sheep, goats, and cattle for meat, milk, and fiber and for strength as draught animals. Recognizing that left unchecked, livestock grazing often resulted in the deterioration of pastures, early grazing management focused on mitigating these adverse effects so that forage could be grazed in a sustainable manner. The regenerative or destructive power of herbivory to shape plant communities has been demonstrated time and time again as humans have managed the grazing of domestic livestock. For better or worse, livestock grazing has been applied in ways that change plant communities. A modern twist on grazing management is to harness the powerful ability of livestock grazing to change the botanical composition of grazing lands and use livestock to manage and control undesirable plants. Targeted grazing, like all managed or prescribed grazing, involves managing the timing, intensity, and season of grazing. However, targeted grazing takes grazing to a higher level with the application of a carefully selected and prepared kind of livestock at a determined season, duration, and intensity to accomplish defined vegetation or landscape goals. Livestock enterprises have been created based solely on offering ecological services for landscape and vegetation management through targeted grazing. As targeted grazing has gained a foothold in the land management arena, both research and experience have evolved to provide land managers and grazing service providers with more definitive tools for managing vegetation. Targeted grazing to manage vegetation and accomplish landscape goals denotes a new frontier in grazing management.

BIG LANDSCAPES, BIG PROBLEMS, BIG OPPORTUNITIES, BIG IDEAS.

Shayla Burnett*

Synergy Resource Solutions, Inc, Belgrade, MT

Too often we work on issues that are critical to us and we are passionate about, but we lose sight of the big picture. Rangelands are not only about managing for a single species, grazing use, or controlling invasives. It is easy for our focus to become “control cheatgrass”, “get more sage grouse”, or “graze more cattle”. Focusing on the big picture can be overwhelming and abstract, but speakers in this symposium will welcome the challenge. It will not “think outside the box” but will present issues and solutions that cannot be defined within a singular box. Rangelands are big, the challenges are big, and the opportunity to make things better is big. This symposium will consist of 4 invited speakers presenting innovative, overarching solutions for the complex problems facing rangelands today. It will conclude with a panel discussion, and we encourage attendees to bring their big questions and solutions. Our goal is to avoid arguing about the details of how to build a better fence but to explore if we need a fence at all. 1:00 pm Introduction 1:10 pm Opening Speaker 1:50 pm Michael Wilbur Vice President of Business Development and Data Services, Wilbur-Ellis 2:30 pm BREAK 2:45 pm Gregg Simonds President, Open Range Consulting 3:25 pm Final Speaker 4:05 pm Wrap Up 4:15 pm Panel Discussion

HOW TO GET PUBLISHED IN RANGELAND ECOLOGY & MANAGEMENT.

Kelly Fogarty*

SRM, Littleton, CO

Presenters: Roger Sheley, Editor-in-Chief; Danielle Descoteaux, Publisher (Elsevier) This workshop, with the new Editor in Chief of REM, is an opportunity to learn more about the aims and scope of the SRM's research journal, and how to prepare, structure, and write your article to increase your likelihood of being published. Especially useful for early career researchers, this workshop is a good opportunity to learn (or brush up on) some tips for publishing success.

BIGHORN SHEEP IN TEXAS AND NORTHERN MEXICO: A COMMON RESOURCE.

Carlos E. Gonzalez*[1], Louis A. Harveson[2], Thomas S. Janke[2], Joshua Cross[2], Froylan Hernandez[3]

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In the late 1800s, there were believed to be 1,500 desert bighorn (*Ovis canadensis mexicana*) roaming throughout 16 mountain ranges in the Trans-Pecos region of Texas. However, Texas lost all of its native desert bighorn during the mid-1900s, as well in Mexico, the states of Chihuahua, Coahuila, and Nuevo Leon lost their desert bighorn. Causes are believed to be associated with overgrazing of domestic sheep, diseases, predation, fragmentation of land, and overhunting. Beginning in 1959, translocation efforts initiated in Texas to restore desert bighorn to their historic habitats. Since 2010 to 2015, 172 bighorn (63 rams and 109 ewes), of 246 captured and released, have been fitted with GPS radio collars for research purposes. Over the last 4 years, we have investigated 53 bighorn mortalities in the Big Bend area and Mexico. During the 3-year study at Big Bend Ranch State Park (BBRSP), 54 collars were successfully recovered. These collars have produced over 100,000 GPS points for our analysis. Twenty one (39%) of the 54 collared bighorn were documented crossing into Mexico and 18 (33%) ventured onto private lands outside of BBRSP. The states of Chihuahua and Coahuila initiated restoration efforts in 2000 in breeding areas where they have successfully increased their populations. As of June 2012, there were 4 captive breeding desert bighorn sheep herds in Chihuahua. And there it is reported to have been 281 desert bighorn sheep at the time in that state. Our restoration efforts are on a larger scale than previously thought with desert bighorn crossing international borders. The knowledge gained from our studies will continue bettering our understanding of bighorn restoration and conservation efforts in Texas, and in the Chihuahuan Desert. Without collaborative conservation (public, private, and international), the desert bighorn sheep restoration program would not be as successful as it is today.

ESTIMATION OF FORAGE POTENTIAL OF DRY SCRUBLAND BY REFLECTANCE.

Aldo Sales*[1], Carlos Villalobos[1], Pedro Martínez-Hernández[2], Jorge Castrellon[2]

[1]Texas Tech University, Lubbock, TX, [2]Universidad autónoma Chapingo, Texcoco, Mexico

The identification and development of methodologies to facilitate sustainable rangeland management are essential for management of ecosystems supporting livestock production. Remote sensing could be an inexpensive method to determine forage production over large areas. However, most studies using this technology for biomass determination in rangelands were conducted in flat areas with uniform canopy. Using a multispectral sensor, we attempted to develop a regression model for determination of standing crop biomass in a dry scrubland in Mexico. The study was conducted from April 2009 to July 2010 at two field sites supporting dry-scrubland vegetation. The sites had different topographic and soil features, but similar vegetation types. Each site covered 225 hectares with 153 samples-plot. We collected samples four times throughout the year (two in the dry season, two in the rainy season). A multispectral sample nd a vegetation clip sample were taken in each plot. A radiometer multispectral sensor was located on a platform 3.2 meters above the soil surface. The sample reading covered an area of 1.6 m, which was the same area used for clipped sample. The reflectance values were used to derive an index of the reflectance (NDVI). Based on the NDVI and clipped biomass data, regression models were developed to predict the biomass production for the two seasons (dry and rainy). The coefficient of determination showed a high variability, varying between 0.14 in the dry season and 0.30 in the rainy season. The variability in the canopy height in shrub vegetation is a limiting factor to consider when using remote sensing. It was concluded that reflectance was not a good estimator of the amount of forage in dry scrubland. Consequently, improvements should be made before optical techniques are used in this type of studies.

DEVELOPMENT OF FINE-LEAVED FESTUCA GRASS FOR FORAGE AND WILDFIRE CONTROL IN THE GREAT BASIN.

Jack E. Staub*, Matthew D. Robbins, Shaun Bushman

USDA ARS Forage and Range Research Laboratory, Logan, UT

Drought and heat tolerant fine-leaved fescue (*Festuca* ssp.) grasses have potential as components in rangeland greenstrips for wildfire control in semi-arid climates, although such grasses have not been evaluated under rangeland conditions. Therefore, 64 geographically diverse *Festuca* accessions of 12 species were evaluated for vigor, color, and biomass in 2009 and 2010 in North Logan, UT to identify grasses for use in U.S. western rangelands. Single plants representing seven species from the 18 best performing accessions in 2009 were selected for plant improvement. Controlled biparental matings among these selections in 2010 produced 18 populations that were evaluated with five commercial *Festuca* checks in replicated trials between 2012 to 2013 at Malta, ID, Blue Creek, UT, and North Logan, UT, where mean annual precipitation is 265 mm, 362 mm, and 484 mm, respectively. Plants were evaluated for color, relative vigor, biomass, seed yield, persistence, and regrowth over two years. Generally, four fine-leaved populations (R4S4, R4S6, R4S22, and R4S32) with parents originating from Turkey (*F. valesiaca* subsp. *valesiaca*), Russia (*F. valesiaca*, *F. valesiaca* subsp. *valesiaca*), Iran (*F. valesiaca*), and the U.S. (*F. ovina*) performed equal to or better than 'Durar' or 'Covar' checks. In Malta (harshest environment), the performance of these four populations compared to 'Durar' was 84-210% for vigor, 79-90% for color, 65-562% for biomass, 64-296% for seed yield, 92-117% for persistence, and 164-454% for regrowth, where R4S22 was superior. AFLP analysis indicated that all four populations were distinct, and that R4S4 and R4S6 grouped near 'Covar', R4S22 clustered near 'Black Sheep' and 'Durar', and R4S32 was genetically unique.

RIPARIAN ESD, ECOHYDROLOGY AND HYDROGEOMORPHIC (HGM) CONCEPTS FOR ESD&RSQUO;S.

Craig Goodwin*[1], Richard Weber[2], Ken Spaeth[3]

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Ecological Site descriptions for landscapes dominated by the influence of water are unique because the drivers of change are dominated by hydrology. Water provides the energy to form and maintain landforms, creates anaerobic conditions needed to perform unique bio-geochemical wetland functions, supports the form and function of stream reaches, and supports unique plant communities dominated by hydrophytic species. Surface runoff and sub-surface flow moves through the landscape from interfluves to watershed outlets in a continuum. Each discrete ecological site along this continuum has its own water budget consisting of inputs, outputs, and storage capacity. The magnitude and direction of these water budget parameters dictates the potential functions performed, and changes in state are either caused by, or respond directly to changes in these parameters. The Hydrogeomorphic (HGM) landscape classification system was developed specifically for the development of functional assessments of wetlands. However, HGM concepts lend themselves to the description of all sites, whether they are “wet” or “dry”. The three HGM parameters are landscape position, dominant water source, and hydrodynamics. Hydrodynamics is a description of the water budget inputs, outputs, and site storage. Storage can occur in the soil profile and on the surface. Surface storage occurs either as lentic ponded water or as lotic floodwater. In both ESDs and HGM landscape classes, site boundaries can be drawn around aggregations of soils that have the same water budget parameters, support the same plant communities, and have the same responses to disturbances. Watersheds are aggregations of these individual sites. Ideally, each watershed within a given reference domain should consist of a set of ecological sites which have boundaries that fit seamlessly, and through which water moves in a continuum. Those ESDs which fall under the scope of Riparian include those sites which receive surface and groundwater from a watershed source area that is above a certain flow accumulation threshold. Riparian sites includes headwater reaches that may not necessarily meet the wetland hydrology threshold.

ASSESSING GREATER SAGE-GROUSE HABITAT USE AT MULTIPLE SPATIAL SCALES USING REMOTE SENSING AND GIS.

Steven L. Petersen*[1], Chris Balzotti[2]

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Greater sage-grouse (*Centrocercus urophasianus*) are landscape species that depend on sagebrush habitats for survival and reproduction. The influence that sagebrush structure and habitat heterogeneity have on sage-grouse breeding at the landscape scale is critical. The purpose of this presentation is to describe the application of remote sensing and GIS to quantify sagebrush structure at different spatial scales and assess the influence of habitat heterogeneity on sage-grouse habitat use patterns. To compare scales, sagebrush habitats were mapped using NAIP and Landsat TM imagery. With high

resolution images, patch patterns around nest sites were determined and quantified using Fragstats patch metrics. At broader spatial scales, GIS derived predictor variables were generated to assess areas with >5% sagebrush cover. Nesting habitat was modeled using maximum entropy and NPMR to identify areas with highest probability of nest site selection. Combined models had overall accuracy greater than 90% for brood rearing and nest models. Results indicate that identifying habitat selection for sage-grouse is scale dependent and that remote sensing and GIS can be used to improve the prediction of habitat use across varying spatial scales.

RELATING ENVIRONMENTAL CONDITIONS TO SEEDING OUTCOMES: CHALLENGES AND OPPORTUNITIES FOR BETTER RANGELAND RESTORATION DECISION-MAKING.

Bruce A. Roundy*

Brigham Young University, Provo, UT

Inconsistent results from semi-arid rangeland seedings are usually ascribed to a lack of adequate precipitation. Range scientists have traditionally associated potential seeding success with annual precipitation amounts and associated vegetation zones. Because seedings usually fail due to lack of plant establishment, advances in seeding technologies must be based on understanding seed germination timing and seedling development in relation to environmental conditions such as soil water availability and temperature. One example of how this can work was the determination of how germination timing, seminal root growth rates, and development of adventitious roots affect native and introduced grass establishment in the Sonoran Desert grassland. Seed and plant response was related to probability of recurrent summer rainfall, which resulted in the simple recommendation to seed after, rather than before the onset of summer rains. Scientists are now determining the relationship between seeding success and other concerns, such as wind erosion, and specific weather patterns. Tools are being developed to predict weather patterns and environmental conditions associated with seeding outcomes. Scientists are coupling seed and plant response to environmental conditions to predict what kinds of weather patterns support plant establishment for various species. In addition, scientists are determining how to modify germination timing to avoid seedling mortality during post-germination frost or drought. Studies of management processes of funding and approval for range seeding are informing ways to package technology to enhance its application. These advances in science, technology, and applications promise to increase probability of rangeland seeding success.

HABITAT AND WILDLIFE RECOVERY EFFORTS IN NORTHERN MEXICO: MAKING IT WORK.

Jorge G. Villarreal-Gonzalez*

Consejo Estatal de Flora y Fauna de Nuevo Leon, Monterray, Mexico

Wildlife conservation and management perspectives in northern Mexico have changed dramatically in the last few decades. A long time has passed since white-tailed deer (*Odocoileus virginianus)* almost became extinct because of overhunting and health problems such as screwworms. Currently itis possible to find ranches where white-tailed deer is overabundant. The interest of ranchers for wildlife conservation and management is related to de additional income that may be obtained from sport

hunting. Exemplary cases of wildlife restoration can be found across northern Mexico. La Cuenca Palo Blanco located in the state of Nuevo Leon covers an extension of 130,000 ha of natural ecosystems that were repopulated with white-tailed deer in 1994. After the repopulation of white-tailed deer the owners of the 53 management units have changed their attitude towards conservation, the sport hunting is providing additional income to ranches. Other benefits of the wildlife restoration programs include the presence of 145 bird species, 34 species of mammals, over 30 cacti species and over 800 plant species representing 37, 24, 30, an 32% of the fauna and flora of the state of Nuevo Leon, respectively. Some of the species existing at the Cuenca Palo Blanco include black bear (*Ursus americanus*), vireo gorrinegro (*vireo atricapillus*), y maguey de hoja ovalada (*Agavevictoriae-reginae*) among others. In northern Mexico conservation programs need to be tied to an increase in the productivity and profitability of ranches, we must understand that ranchers making a living out of their operations need that kind of incentives to be motivated to establish management and conservation programs.

CONTROLLING HONEY LOCUST WITH HERBICIDE IN GRAZED PASTURES.

Keith Harmoney*

Kansas St. University, Hays, KS

Honey locust is a deciduous tree that produces large brown seed pods and thorny appendages. Fire suppression and the introduction of honey locust into shelter belts has allowed honey locust to increase in the southern mixed grass prairie region. Because locust trees produce prolific sprouts, mechanically cutting trees seldom results in complete tree mortality. Trees 3-8 inches in diameter were treated with one of five combinations of herbicides and application methods to test for control. Treatment combinations, on a volume:volume basis, included: 1) triclopyr 25% + diesel 75% and 2) aminopyralid 5% + bark oil 95%, both applied to the lower 15 inches of basal bark including the root collar area of live trees, as well as 3) triclopyr 25% + diesel 75%, 4) aminopyralid 10% + water 90%, and 5) dicamba 33% + 2,4-D 2% + water 65%, all applied immediately to the outer cambium layer of cut stumps. One year after treatment, aminopyralid applied as a basal bark or as a cut stump treatment had the best control and averaged over 97% dead trees. The triclopyr + diesel cut stump treatment had fewer dead trees (just over 50%) than any other treatment and produced many new sprouts. In grazed pasture, treating stumps with aminopyralid + water and treating standing trees with a basal bark application of aminopyralid + oil were two effective control options. Triclopyr + diesel was better at controlling live standing trees with a basal bark treatment rather than as a cut stump treatment.

USING EARTH SENSE TECHNOLOGY TO ASSESS THE STATE OF ECOLOGICAL SITES OVER LARGE GEOGRAPHIC AREAS.

Gregg E. Simonds*, Seth Simonds, Eric D. Sant

Open Range Consulting, Park City, UT

Ecological site descriptions (ESDs) are reports that describe an Ecological Site's soils and potential plant communities. These ESDs are used by federal land management agencies to govern stocking rates, prescriptions in site restoration, and managing wildlife habitat. A core part of ESDs are the state-and-

transition model (STM). STMs describe how vegetation will respond to management and natural processes. What limits the efficacy of these models is not knowing the current vegetation or state on described ecological sites. Open Range Consulting (ORC) has developed technology capable of assessing functional ground cover conditions that can be used to evaluate the state of ecological sites across large geographic areas at 1 meter resolution. This technology offers the potential to map the current state of ecological sites. This can be done over broad regions quickly and inexpensively. Having high resolution and spatially explicit maps of the states of ecological sites on a regional scale enriches the value of ESDs. It provides planners with a decision support tool to make precise and impactful plans at appropriate scales and then have a means to accurately assess the results.

ASSESSING SAGE-GROUSE HABITAT USING TELEMETRY AND REMOTE SENSING TECHNOLOGY.

Gregg E. Simonds, Eric D. Sant*

Open Range Consulting, Park City, UT

Conserving and enhancing Sage-Grouse habitat requires accurate and precise delineation of sagebrush and other functional ground cover conditions. With a spatially precise representation of habitat - wildlife managers can create plans and that focus on conserving high value habitat, enhancing moderate habitat, while identifying poor habitat. Thus, plans can be created that have the greatest effects on sage grouse populations. Ideally, the efficacy and success of these plans should then be assessed. Using 4,000 radio telemetry Sage-Grouse observations Open Range Consulting created habitat maps from two remotely sensed data sets. The first dataset was the 30m Landfire EVT that is generally being used by the federal agencies to assess sage grouse habitat. The second dataset was Open Range Consulting's (ORC) 1m Earth Sense Technology (EST). ORC's EST provided the accurate and precise delineation of functional ground cover conditions that is necessary in making, implementing, and monitoring Sage-Grouse management plans at the spatial scales described in the Sage-Grouse Habitat Assessment Framework.

HEALING 140 MILES OF RIPARIAN AREAS-THE SQUAW VALLEY SUCCESS STORY.

Gregg E. Simonds, Eric D. Sant*

Open Range Consulting, Park City, UT

The Squaw Valley Allotment, located in northeastern Elko County, Nevada, includes a mixture of both private and public lands administered by the Bureau of Land Management (BLM). The allotment consists of an entire watershed that supports Lahontan Cutthroat Trout, a species on the Federal list of endangered wildlife. Prior to 2004 the allotment was grazed by cattle all season. In 2004, a grazing goal was implemented to have more years of hot season (July-August) rest than use on the riparian areas in a 10-year term without reducing overall stocking rate. Since this goal was implemented, the number of miles of stream evaluated as properly funcitoning increased from four to 94. Riparian vegetation increased six fold, there was a five fold increase in the number of beaver ponds, and there are 33 additional miles of riparian habitat. These results indicate the potential for dramatic improvement of riparian areas by adjusting the timing of grazing and recovery without reducing stocking rate.

ADMINISTRATION OF PUBLIC GRAZING LEASES THROUGH RESULTS DRIVEN GRAZING AND ELIMINATING &LDQUO;TERMS AND CONDITIONS&RDQUO;.

Gregg E. Simonds*, Seth Simonds, Eric D. Sant

Open Range Consulting, Park City, UT

Rangeland production and recovery is highly variable and depends primarily on the timing and amount of precipitation. Ranch managers attempting to manage highly variable forage production can be compared to captains of sail boats who rely on equally fickle wind. The normal 10 year grazing lease with fixed terms and conditions effectively lock the rancher's sail and rudder to expectations of average conditions. Average conditions will never be the actual conditions faced by the ranch manager no matter how thoroughly vetted by best science. This policy will doom both ranchers and public lands to financial and ecological failure. To unlock the ranch manager's sail and rudder, grazing needs to be "results driven" with long-term results and goals established for each allotment congruent with rangeland health. These goals must be measureable so ranchers can be held accountable. In exchange, they must be granted flexibility within the allowed season of use and stocking rate to meet their goals. This type of rangeland management and administration requires accurate, timely, and cost effective assessment technology to monitor the impact of management practices, create trust, and allow for innovation and profitability.

MANAGING RIPARIAN HABITAT FOR BULL TROUT USING STOCKMANSHIP.

Steve Cote*

Cattle Sense, Paris, TN

In Central Idaho, there are mountainous grazing allotments with canyons and narrow creeks that are Bull Trout habitat. Bull Trout are a threatened species and, at least in areas like the Little Lost River drainage, affected by a number of difficult to address resource issues like dewatering, predation and in-stream barriers. One element that can be readily addressed however is improved streambank cover and habitat complexity (and sediment and temperature to some extent). Stubble height and other standards on riparian areas have been increased in an attempt to enhance this element but it has proven nearly impossible for ranchers to meet these with traditional riding and management. Experience has shown that remarkable positive apparent trends can occur however when collaborative efforts produce a good range resource plan and Bud Williams stockmanship is employed. Time after time, precise control over the time that riparian soils and vegetation are exposed to cattle has resulted in improved soil conditions and bio-diversity. A video has been produced showing association riders that have obtained this control over the results of grazing, getting one herd to stay where they put them and eliminating riparian loafing behavior. There are some key riparian soils and plant factors to consider that are discussed also. The future challenge, in my view, is not proving whether this tool has the potential to help improve range resources significantly, but how to get riders and ranchers to adopt it completely and sustain its use. Good stockmanship is not hard to do and produces profound changes in livestock behavior but requires fundamental changes in ranchers (riders) beliefs about handling cattle.

Widespread use of stockmanship depends on facilitating changes in this belief and the training of more teachers and riders.

USING ADAPTIVE MANAGEMENT TO MANIPULATE WHERE CATTLE GRAZE.

Derek W. Bailey*

New Mexico State University, Las Cruces, NM

Distribution is a critical tenet of livestock grazing management. Improvement of grazing distribution is often part of the rationale for implementing a grazing system. However, increasing stocking density by reducing pasture size or increasing herd size does not necessarily improve uniformity of grazing. Strategic placement of fences and reducing pasture size are useful tools to modify grazing distribution, but other techniques can be equally, and sometime more, effective. Water developments are powerful tools for improving distribution and they are often an overlooked benefit of implementation of rotational grazing systems. Unfortunately, development of water does not always resolve concerns with uneven grazing. One of the most powerful tools for modifying cattle distribution is to manipulate when the pasture is grazed. For example, grazing during late spring and early summer can reduce cattle use of riparian areas compared to grazing in mid to late summer. Use of adapted animals can increase of rugged terrain and areas that are far from water compared to naïve and unadapted cattle. During periods when the forage is dormant, strategic supplement placement can be used to lure cattle to underutilized areas. Low-stress herding is a labor intensive but effective approach to reduce time cattle spend in riparian areas. When combined with strategic supplement placement, low stress stockmanship can be used to target cattle grazing. The key to successively modifying cattle grazing distribution is to consider and test one or more management tools that address site-specific distribution concerns and then evaluate their success and refine promising practices.

FROM THE CONFERENCE TABLE TO COMMUNITY OF PRACTICE: THE PATCH BURN GRAZING WORKING GROUP.

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The Patch Burn Grazing Working Group began as a group of researchers and land managers working to coordinate learning on pyric herbivory. The meeting of the minds led to a listserv and annual meetings that included state-of-the-science presentations and field trips. The composition of the group also expanded to include landowners and practitioners to the extent that the landowners outnumbered the agency and university staff at the last meeting. Support for the meetings similarly evolved. This paper will discuss results from a survey to understand member satisfaction and the impact of this community of practice on land management of the Great Plains.

STOCKMANSHIP FOR ACHIEVING RANGELAND MANAGEMENT GOALS.

Derek W. Bailey*

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Stockmanship or low-stress livestock handling techniques developed by Budd Williams are not typically considered as tools to manage rangelands. Most land managers and livestock producers would describe proper stockmanship as potentially beneficial for moving livestock from one pasture to another and for handling cattle in corrals as part of their normal husbandry practices. However, stockmanship can be used to manipulate livestock distribution and target grazing. Cattle often congregate along riparian areas, which can adversely impact the integrity of streambanks and fishery habitat. On public lands, stubble height standards are used to minimize adverse impacts of livestock on riparian areas. When cattle were herding away from riparian areas at midday, stubble heights of riparian graminoids were higher than in control pastures where cattle were allows to roam freely. Strategic placement of low-moisture block (LMB) protein supplements can increase cattle fidelity to nearby areas, and naturally stops cattle movement when they are herded to LMB placements. The combination of stockmanship and strategic supplement placement can be used to focus cattle grazing in rugged terrain and/or areas far from water. Focused cattle grazing has the potential to improve forage quality and habitat for wild ungulates and help manage fine fuels and the risk of catastrophic wildfire. Traditional approaches to modify cattle distribution such as fencing and water developments may conflict with other resource uses including wildlife and recreation. Although labor intensive, stockmanship can be successfully used to manipulate livestock grazing distribution where management techniques to manipulate cattle movements may not be feasible or desirable.

BLM'S APPROACH TO LENTIC MONITORING.

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Monitoring lentic systems is imperative to the Bureau of Land Management's (BLM) multiple-use mandate directing management of watersheds for activities that potentially impact lentic resources, such as livestock grazing, timber harvesting, mining, energy development, and recreation. Consequently, knowing the condition and trend of lentic systems is also critical to achieving the BLM mission to "sustain the health, diversity, and productivity of the public lands for the use and enjoyment of present and future generations." To more effectively evaluate resource condition across landscapes, and as a result of different management objectives that transcend traditional local boundaries, the BLM adopted a landscape approach and developed the Assessment, Inventory, and Monitoring (AIM) Strategy in 2011. The AIM Strategy is a national framework designed to facilitate integrated, cross-program resource monitoring at multiple spatial scales of management. Specifically through the AIM Strategy, the BLM seeks to integrate both local- and regional-scale monitoring activities to inform condition assessments by establishing core indicators, standardizing field methodologies, and developing electronic data capture and storage technologies. As a component of the AIM Strategy, the National Aquatic Monitoring Framework (NAMF) provides the rationale and framework for how the BLM can quantitatively monitor and assess the conditions of aquatic resources, including lentic areas. To address these needs, an interdisciplinary working group has been assembled to establish core indicators for lentic systems

sampled under the AIM strategy. The selection of lentic indicators follows a process similar to that used to select and validate lotic aquatic core indicators, which includes internal and external peer review. Lentic core indicators address water quality, vegetative cover and composition, plant height, woody species density and age class, and pedestaling. Supplemental indicators, which can be collected in addition to core indicators to monitor use include stubble height and woody species use. A draft protocol has been assembled to provide information to evaluate condition and trend across spatial scales, and different transect layouts can accommodate both systematic random sampling and targeted use-based monitoring. The protocol will be tested in the summer of 2016 for feasibility of field use, and research will be needed to validate sample sufficiency and ability to detect change.

RIPARIAN WETLAND GRAZING MANAGEMENT.

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Lentic wetlands often provide water and forage for livestock and wildlife as well as various ecosystem services. Successful rangeland management maintains or restores riparian function and plants capable of stabilizing soil, especially in the vegetated zone closest to open water. The greenline is where stabilizing vegetation most influences erosion, landform, and water quality. The whole width of the riparian buffer traps sediment and nutrients and thus maintains water depth and quality. Effective grazing management balances grazing with opportunities for plant growth and/or regrowth by adjusting grazing timing, duration, intensity, and/or variation of timing, duration and intensity. Often, lentic riparian areas occur as small places of green and water and they attract cattle that use it for central place foraging. In many settings, reducing stocking rate without other strategies to fix riparian over-use would severely limit production from the pasture. Grazing managers can emphasize either limiting utilization to decrease stress or accept stress and provide for recovery. This choice greatly effects management actions, use criteria, and methods for short-term monitoring. To meet objectives and encourage riparian recovery, managers use many grazing strategies that allow rather than impede riparian recovery. Adaptive management adjusts actions using short-term monitoring that is focused on chosen strategies. Long-term monitoring focused on objectives helps adjust management as needed for priority areas needing functions, and then desired resource values. Once riparian areas are properly functioning, managers have greater flexibility for adjusting management for continued success.

GRAZING AND CONSERVATION OF ARIDLAND AQUATIC SPECIES-ARE EXCLOSURES THE BEST STRATEGY?

Cynthia Tait*

Forest Service, Ogden, UT

While the negative effects of intense livestock grazing on aridland aquatic species, such as desert fishes and amphibians, are well documented, less is known about impacts of more moderate grazing regimes, including variations in timing, duration, and intensity. Historically, land managers across the Great Basin reacted to overgrazing in lentic wetlands by building fenced exclosures. Frequently, however, recovering

vegetation attains densities that occlude open water and banks, and managers resort to mowing or mechanically excavating the site to maintain optimal habitat for aquatic species. Evidence that is largely anecdotal suggests that these species benefit from a mosaic of vegetation densities and compositions. It may be that some level of well-managed grazing can achieve desired habitat conditions in wetlands if care is taken regarding intensity, seasonal timing, protection of breeding sites, and sufficient residual stubble to ensure adequate cover.

WATER DEVELOPMENTS AT SPRINGS: CONSIDERATIONS FOR DESIGN, CONSTRUCTION, MAINTENANCE AND RESTORATION.

Joe Gurrieri*

Forest Service, Golden, CO

Flow regulation structures at springs and wetlands designed to capture and divert water for livestock watering, are ubiquitous on western rangelands. Historically, the goal for a successful spring development was to maximize the amount of spring flow captured. The result has been dewatering of large numbers of aquatic habitats across the west. Today, the water needs of spring habitats and the overall ecological health of the local aquatic and terrestrial system are of equal or more importance. A cadre of ecologists, hydrologists, range conservationists and other specialists with experience in spring evaluation, monitoring and development, has recently worked on a series of considerations for water developments at springs. These considerations include innovative designs, best management practices for construction and maintenance of developments, and ideas for successful restoration.

SPRINGS OF THE CROOKED RIVER BASIN, OREGON: INVENTORY AND OPPORTUNITIES FOR RESTORATION.

Allison Aldous*, Zach Freed, Emilie Blevins

The Nature Conservancy, Portland, OR

Springs in semi-arid landscapes such as Oregon's Crooked River Basin are important habitat for freshwater biodiversity because they provide oases of perennial water supply in a water-limited environment. Springs also are important to local economies because they are frequently developed for livestock water supply. Very little is known about aridland springs in Oregon; however, studies from other western states estimate approximately 90% are ecologically impaired because developments are not protective of ecological function (Stevens and Meretsky 2008). To address this issue, we undertook a multi-year project to inventory spring ecological types, assess their condition, and evaluate opportunities for protection and restoration. Since 2013, we have inventoried 94 springs and spring complexes (clusters of springs) of the nearly 2000 that are mapped in the basin. Of the inventoried springs, 69% are rheocrene (discrete orifice associated with a springbrook), 22% are hillslope (diffuse orifice and not accumulating peat), and 9% are helocrene (diffuse orifice, possibly peat-accumulating fens). Flow rates are highest for the rheocrene springs (mean=7.6 gpm, se=1.5) compared to hillslope (mean=1.9 gpm, se=0.6) and helocrene springs (mean=1.8 gpm, se=1.2). Biological inventories of a subset of higher flow rheocrene springs show they support significant populations of spring-dependent

species, including spring snails, bryophytes, vascular plants, and amphibians. Field inventories also indicate that more than 80% of springs in the Crooked Basin have been developed for livestock watering, and the vast majority of these are developments are not protective of the spring ecosystem due to lack of or neglect of protective structures such as fences. To improve conservation of springs across the basin, we are taking a two-fold approach. On springs where water developments are no longer needed, we are testing methods for complete spring restoration. Where developments are still needed for livestock, we are testing some simple spring development designs that will meet both ecological and economic needs by splitting the water in a way that provides clean water for livestock while leaving water in the spring to support the spring ecosystem.

PHYLOGEOGRAPHY OF THE BOBWHITE QUAILS.

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The bobwhites (*Colinus*) consist of 3 grassland-associated, allopatric species of New World quails: the northern bobwhite (*C. virginianus*) ranges from the eastern US to Guatemala; the black-throated bobwhite (*C. nigrogularis*) in the Yucatán Peninsula, Nicaragua, and Honduras; and the crested bobwhite (*C. cristatus*) from Guatemala to northern Brazil. We used mitochondrial DNA (mtDNA) sequences from museum specimens to study the phylogeography of the 3 species and evaluated the conclusions using ecological niche models. *Colinus* was composed of 2 deeply divergent lineages, the crested bobwhite and northern and black–throated bobwhites, both of which were genetically distinct. The northern bobwhite was displayed evidence of past demographic and geographic expansion, but no phylogeographic structure. Ecological niche modeling was congruent with a recent range expansion for the northern bobwhite from Late Pleistocene refugia in Mexico and the southeastern US. The black–throated bobwhites from the Yucatán Peninsula were distinct from those in Nicaragua, with little evidence of population expansion. Ecological niche modeling suggested that the fragmented distribution of the black–throated bobwhite has existed for the past 130,000 years. Although the crested bobwhite displayed little evidence of population expansion, the mtDNA data revealed 3–4 geographically and genetically distinct lineages. Results of niche modeling suggest that the crested bobwhite had a much wider distribution in Central and South America during the Last Glacial Maximum. All 3 species exhibited evidence of range contraction 130,000 years ago during the Last Interglacial. Given the sensitivity of all 3 bobwhites to climatic cycles, managers should consider impacts of current global warming when crafting conservation plans.

DOES GRAZING PERIOD LENGTH EFFECT ABOVEGROUND PRODUCTION AND HETEROGENEITY OF RANGELAND VEGETATION?

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Grazing strategies on range and pasture commonly are designed with grazing period length as a focus. Grazing period length can affect recovery period length and grazing pressure; thereby, possibly impacting aboveground plant production and heterogeneity of vegetation structure and composition. We are quantifying plant production, composition, and structural heterogeneity on upland pastures (sands ecological site) in the Nebraska Sandhills in response to different combinations of cattle grazing and recovery period lengths. Three grazing period lengths at each of two stocking rates are being tested on upland pastures grazed annually by cattle from mid-May to mid-October since 2010. Grazing period lengths are 3 days in a 50-pasture rotation, 37 days in a 4-pasture rotation, and 150 days in continuously-stocked pastures. Stocking rates are 1.9 AUM/ha (recommended) and 2.7 AUM/ha (1.5x). Plant functional group composition and aboveground production is estimated by clipping standing vegetation at ground level in 20 grazing exclosures (1 m2) per pasture in mid-August. Stubble heights are measured within 2 days following termination of grazing to estimate utilization and heterogeneity (variance among sampling points) by topographic position and pasture. Botanical composition and aboveground production response to grazing period length is trending towards interacting with stocking rate as aboveground production is relatively low at the 1.5x stocking rate on continuously-stocked pastures. Although 1.5x pastures have shorter post-grazing stubble height than the moderately-stocked pastures, stubble height among the grazing period length treatments generally has not differed. However, low-lying interdunal areas tend to be grazed to lower stubble heights in continuously-stocked pastures, thus favoring short grasses in this topographic position. Botanical composition response to grazing period length and stocking rate also will be reported.

EFFECTS OF MOWING AND HERBICIDE TREATMENTS ON THE NUTRITIONAL QUALITY OF SAGEBRUSH IN CENTRAL WYOMING.

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Wyoming big sagebrush (*Artemisia tridentata wyomingensis*) is the most widely distributed subspecies of big sagebrush and has been treated through chemical application, mechanical treatments, and prescribed burning to improve habitat conditions for species such as greater sage-grouse (*Centrocercus urophasianus*) and mule deer (*Odocoileus hemionus*). Although the response of structural attributes of sagebrush communities to treatments is well understood, there is a need to identify how sagebrush treatments influence the quality of winter food available for wildlife. The purpose of our research was to identify how mowing and herbicide treatments intended to reduce sagebrush canopy cover influenced dietary quality of Wyoming big sagebrush in central Wyoming. Two study areas were mowed in January and February 2014 and herbicide was applied in two study areas in May 2014. We constructed six exclosures in each study area (24 total), which encompassed 30 m X 30 m areas of treated and untreated sagebrush within each exclosure. Samples of current annual growth were collected from 18 sagebrush plants from treatment sites and 12 plants from control sites within each exclosure during November 2013 and 2014. Samples were analyzed for crude protein and secondary metabolites known to influence dietary selection of sagebrush by sage-grouse and other species. Preliminary results suggest that mowing treatments may slightly increase nutrient concentrations directly after treatments without immediate changes in secondary metabolites. Assessing dietary quality during additional years following treatments and potential trade-offs with loss of biomass associated with treatments will allow us to

determine the influence of sagebrush treatments on dietary quality for sage-grouse and other co-occurring wildlife.

A USDA FOREST SERVICE PERSPECTIVE ON RANGELAND MANAGEMENT SPECIALIST GS 0454 HIRING NEEDS.

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In recent years numerous changes have occurred affecting hiring prospects for public land management agencies. During a period of time when agency budgets were reduced and vacancy positions were scarce, universities providing rangeland management degrees experienced lower enrollment in rangeland ecology programs. Over the course of two decades, university department names and course descriptions were changed to attract a broader number of prospective students. At the same time fewer natural resource hiring officials with experience evaluating rangeland ecology and management university curriculums remained in the Forest Service. Fewer people were asked to do more with reduced financial resources. As a result some applicants for public land management vacancies were deemed unqualified, in part, due to a lack of knowledge about natural resource vocabulary, terminology in course descriptions of university catalogs and interpretation of course titles. In the meantime, new perspectives on agency skill needs, educational needs, technnological advances and agency hiring expereince have not kept pace with each other. We now have a need to reconciling agency needs, interpretations of hiring standards with hiring practices to construct an updated and clear description of requirements for the rangeland management GS 0454 entry level standard.

FORESTLAND ESD CONCEPTS AND CURRENT DEVELOPMENT IN NRCS.

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USDA-NRCS, Greensboro, NC

Ecological Site concepts originated on western rangelands but have been extended to forestland and can be applied to all lands. Development of Ecological Site Descriptions on forestland has been limited, especially east of the Mississippi River. The diversity of plant communities, topography and soils in the eastern US makes ESDs especially challenging but also potentially useful. Lack of familiarity with ESD concepts by most resource professionals in the east has also slowed progress. Recent NRCS staffing of Ecological Site Inventory specialists in Eastern states has resulted in renewed interest in forestland ESDs and an increased awareness of the ecological site concepts by both NRCS and partners. Technical Teams to support ESD development have formed in several states. The current state and potential for growth of ecological site concepts in the largely tree-covered eastern US will be described in this presentation. Examples of recent ESD development will be presented.

EVOLVING CONCEPTS OF MANAGEMENT AT THE BADER RANCH - KIM, COLORADO.

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Colorado State University, Fort Collins, CO

Southeast Colorado has been in a severe drought since 2000. Since drought and the associated factors are endemic in southeastern Colorado, the ranch has developed an on-going evolution of management and decision processes to adapt to that ever changing environment. In 2002, the rainfall was so little that no growth was present on the perennial plants, this precipitated an unwelcome but necessary decision to destock the ranch. The management has been at a reduced stocking rate ever since. The Ranch has had a large wildfire, periodic floods and outbreaks of grasshoppers. This has caused the ranch to develop a systematic approach to their decision process that incorporates observation, monitoring, forecasting, adaptation and implementation into their management framework to the ranch operation. To date, this approach has allowed range to recover and prosper beyond what was once possible even though the drought persists and for a gradual restocking of the range as changes in resource capability warrants it.

HIRING ENTRY LEVEL RANGELAND MANAGEMENT SPECIALISTS AT BLM.

Richard Mayberry*

USDI Bureau of Land Management, Gettysburg, PA

The author will present information regarding needs and expectations for entry level rangeland management specialist (RMS) positions in the Bureau of Land Management (BLM). Skill sets, knowledge, roles and responsibilities expected of an entry level RMS have changed in the last decade. The author will also discuss recruiting and hiring processes used by the BLM. The information provided by the author will be used to assist the workshop participants with identifying and resolving disconnects between educational curricula and BLM expectations for RMS applicants.

PRAIRIE DOGS: RANGELAND PESTS OR UNEXPECTED ALLIES IN GRASSLAND MANAGEMENT?

Sarah L. Hale*, John L. Koprowski, Steven R. Archer

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Woody encroachment is a widespread phenomenon affecting grasslands and savannas worldwide. While its effects vary widely depending on local conditions, encroachment often can have adverse effects on an ecosystem. Several causes have been proposed in the literature, such as grazing of domestic livestock, fire suppression, climate change, and increasing atmospheric CO2 levels; however, the widespread removal of a native grazer, and keystone species, the prairie dog (*Cynomys* spp.), is one potential cause that has received little attention in North America. Prairie dogs physically alter their environment by burrowing, foraging, and maintaining short vegetation on their colonies, which provides habitat and shelter for other species, creates macropores for water percolation, turns over soil, provides young nutritious plant shoots for grazers, creates fire breaks in grasslands, and potentially suppresses woody plant growth. Despite their many services, prairie dogs have been considered pests range wide, and many eradication programs, some state and federally sponsored, were carried out beginning in the

early 1900s. Because of these eradication programs, the black-tailed prairie dog (*Cynomys ludovicianus*; hereafter BTPD) was extirpated from Arizona by 1960, but has recently been reestablished to Las Cienegas National Conservation Area in southeastern Arizona. Our study aimed to determine if/how these recently reestablished prairie dogs were influencing the grassland ecosystem. We measured soil nutrient content on colonies and at nearby control sites, installed exclosures around woody plants, and conducted artificial sapling experiments on and around BTPD colonies. We found that prairie dog burrows contained higher concentrations of several nutrients than control sites, and that prairie dogs were having a significant effect on woody plants on their colonies. Our findings suggest that the reestablishment of this highly persecuted, yet ecologically critical species could simultaneously function as a management tool for degraded rangelands across the North American West.

PERSPECTIVES ON THE CURRICULUM STANDARDS FOR ACCREDITED RANGELAND MANAGEMENT PROGRAMS.

Merwyn M. Kothmann*

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Qualifications for the 454 series were last updated during the 1970's and the SRM curriculum standards for accreditation of range programs were developed at the same time. The SRM Accreditation Handbook was revised in 2005, but there were only minor modifications to the curriculum standard. This presentation will present and discuss the curriculum standard in the accreditation handbook and evaluate how university programs have changed in the past 40 years. Workshop participants will be encouraged to evaluate the current curriculum standard relative to the current needs of agencies hiring under the 454 series. The objective is to evaluate whether changes should be proposed for the Accreditation Handbook.

CHALLENGES AND DISCONNECTS FOR DIVERSITY RECRUITMENT IN NATURAL RESOURCE MANAGEMENT.

Diana L. Doan-Crider*

Texas A&M University, Medina, TX

Minority representation in natural resources is already challenging due to complex cultural and demographic issues. However, recent changes to federal hiring regulations have further obstructed underrepresented students from entering into federally classified "mission critical" career paths. We recently conducted a series of workshops comprised of academic, agency, and non-profit stakeholders to 1) identify disconnects in federal minority recruitment and retention in natural resources, 2) develop action items and strategies to address those disconnects, and 3) identify areas that need further assessment. Challenges in recruitment were identified as early as K-12, likely resulting from declining experiential activities and funding for natural sciences, lack of parental support for agricultural and natural resource career paths, and poor tracking and mentoring for children who do show interest in those areas. Furthermore, early career counseling and poor understanding about mission critical career path options is likely misguiding students to enter into schools and programs that do not meet Office of Personnel Management curriculum requirements for those positions. In addition, confusion due to

recent changes in the federal employment process and internship programs, such as Pathways, has contributed to a dramatic decline in minority recruitment numbers. This is compounded by waning agency/university relationships, resulting in poor internship participation, student career tracking, and ultimately lower numbers in the federal workforce. Students meet additional challenges when they find that educational funding opportunities tend to focus on high academic achievement, and that the nationally competitive federal employment system is somewhat inflexible to cultural and demographic differences. We were able to assign achievable action items to resolve clearly evident disconnects, and we continue to work on long-term strategies for other, more difficult challenges. However, further assessment is needed for some areas.

CHALLENGES AND DISCONNECTS FOR NATIVE AMERICAN STUDENTS IN NATURAL RESOURCE MANAGEMENT.

Diana L. Doan-Crider*

Texas A&M University, Medina, TX

The forum will present a proposed comprehensive “train the trainer” strategy to build capacity for tribal rangeland managers, develop outreach tools for both Native American and Hispano agricultural communities, and help strengthen tribal college curricula and increase recruitment of Native American students into natural resource management. Objectives will include 1) a “train the trainer” tribal rangeland management workshop series; 2) rangeland management toolkits for outreach in both Native American and Hispano land-based communities; 3) evaluation for an accredited online soil and rangeland ecology course for tribal students; and 4) an inter-tribal informational website on rangeland management, which can later be expanded to include all natural resources. Potential partners for this initiative will include the Native American non-profit organizations, land-grant colleges and universities, and tribal and federal natural resource and management agencies. We will ask for input from participants, and discuss implementation strategies. (*)Presentation of the SRM proposal “Native American Rangeland Training and Outreach Program” (*)Audience input about curriculum considerations and tribal needs (*)Presentation of “Disconnects and Challenges for Recruiting Native American Students into Natural Resource Careers” (*)Group participation for further discussion, subsequent workshop planning, and white paper publication

MULTI-SCALE OCCUPANCY ESTIMATION FOR THE LESSER PRARIE-CHICKEN: PRELIMINARY ASSESSMENT.

David Pavlecky[1], Kristen Adachi[2], Fawn Hornsby[2], Lyman McDonald*[3]

[1]Bird Conservancy of the Rockies, Brighton, CO, [2]Western EcoSystems Technology, Inc, Laramie, WY, [3]Western EcoSystem Technology, Laramie, WY

Pilot data based on the Western Association of Fish and Wildlife Agencies (WAFWA) range-wide lesser prairie-chicken survey (LEPC) 2015, supplemented with temporal replication of survey methods on a subset of survey units, were subjected to preliminary modeling the probability of occupancy at multi-scales. We estimated probability of LEPC occupancy at two spatial scales: presence of the LEPC on 15 km X 15 km grid cells and small-scale probability of occupancy on 7.5 km X 7.5 km quadrants nested

within the grid cells. We compared the performance of the WAFWA range-wide survey with the performance of the WAFWA range-wide survey data when supplemented with data from repeated temporal replicates of the survey method. We conducted pilot analyses to evaluate the potential of the multi-scale occupancy model to predict the effects of habitat and conservation practices on LEPC occupancy. Preliminary results indicate that local conservation programs are positively related to LEPC occupancy in surveyed grid cells.

MONITORING RESTORATION EFFORTS THROUGH REMOTE SENSING.

Kenneth Epaloose*, Allen Ellwood, Nathan Apache

Southwestern Indian Polytechnic, Ogden, UT

This project is using aerial photography data to measure the amount of vegetation cover and compare it to traditional rangeland methods. With the help of photo processing software technology, we can take a large number of photos and create an orthophoto of the monitored landscape. The purpose of doing this study is to help rangeland managers with small natural resource departments such as Tribes to reduce the amount of labor and time when doing rangeland projects and implement the use of new available technology. However, the accuracy of this type of data needs to be tested. The hypothesis of this project is that measurements from high resolution aerial photographs will correlate to traditional canopy gap measurements. Currently, the team is testing different methods of collecting data by using a pole mapping method. The team will graduate to a balloon method and eventually to using a drone. Once the methodology is tested, we will use this methodology at the Pottery Mound at the Pueblo of Isleta to help in a rangeland restoration project. By using a drone, the Pueblo of Isleta can fly over the restoration project and get rapid rangeland monitoring photos for use by their Natural Resource Department. The Pottery Mound has historic value to Southwest Tribes of New Mexico and Arizona and contains a large amount of artifacts including pottery shards, human bone fragments, and different tools used by Native Americans from 1100-1400 AD.

DOES HOLISTIC MANAGEMENT® CONTRIBUTE TO EFFECTIVE UTILIZATION OF ADAPTIVE GRAZING STRATEGIES?

Peggy Sechrist*

Certified Educator in Holistic Management, Gillepsie, TX

There can be a world of difference between a range scientist's work and the bottom line for a full time livestock producer. At times, each one's goal may be conflicting; and due to the reductionist nature of science, the resulting recommendation to producers may address one aspect of a producer's operation without fully exploring the functional impact it may have on the whole operation. Holistic Management® provides a framework that guides a producer through a thorough evaluation of the functional relationships within his operation and includes a set of decision-making guidelines for selecting choices to move the producer in a congruent line toward his personal goal. The Holistic Management model also includes a detailed set of planning modules that provide a disciplined approach to application of management tactics coupled with monitoring in order to frequently, if not daily, evaluate whether or

not operational movement is, in fact, moving toward his personal goal. Using this framework, a producer can receive scientific recommendations and effectively evaluate the impact of the recommendation on the whole of the operation and more effectively utilize it to his advantage. Furthermore, continuous monitoring of operations on all levels including grazing provides the necessary feedback for quick and efficient adaptations to keep the operation moving in a positive direction.

COLLABORATING WITH STAKEHOLDERS TO CONDUCT ADAPTIVE GRAZING MANAGEMENT RESEARCH.

Kenneth W. Tate*

University of California, Davis, Davis, CA

We partner with stakeholders to study the effectiveness of adaptive management for social and ecological goals. We integrate social and ecological disciplines to 1) examine on-ranch grazing strategies, factors driving adoption of strategies, and outcomes; and 2) develop novel stakeholder participatory, adaptive management scale grazing experiments. We analyzed mail survey responses from 765 CA and WY ranchers to quantify on-ranch grazing strategies. We found 62% and 5% of ranchers surveyed implement extensive and intensive rotational strategies, respectively. Ranchers most likely to adopt intensive rotational grazing did not list livestock production as a primary goal, while ranchers adopting season-long continuous grazing ranked livestock production as their dominant goal. At an academic research and extension center in CA, we also engaged 58 diverse stakeholders to develop and implement a novel adaptive grazing study based on the goals and strategies they prescribed for testing. Stakeholders included ranchers running a livestock economic enterprise, conservation professionals who use grazing to pursue environmental goals, and professional rangeland managers who serve clientele with diverse goals. The strategies that stakeholders wanted to compare included season-long continuous, as well as extensive and intensive rotational grazing. Despite limited reports of on-ranch intensive rotational grazing by survey respondents, this diverse stakeholder advisory group overwhelmingly recommended intensive rotational grazing as a primary treatment of interest. Grazing management implementation and adaptation decisions are made jointly with our stakeholder advisory group in response to measured progress towards established goals and our collective *experiential* and *experimental* knowledge. We will highlight measured ecosystem service tradeoffs and synergies between grazing strategies, as well as the benefits and challenges of this “bottom-up” network approach to conducting linked social-economic-ecological research at the management scale.

SUSTAINABLE RANCHING IN MEXICO: THE BIRTH OF A NEW PLATFORM FOR TRANSPARENCY AND EVALUATION.

Sula Vanderplank*

BRIT, Ft. Worth, TX

An extension of the highly successful platform in Brazil, Alianca da Terra (AT) in Mexico is a new grass-roots movement for sustainable ranching and habitat conservation, by means of a transparent evaluation and monitoring platform. AT is revolutionizing sustainable ranching by conducting extensive ranch evaluations, then asking ranchers to commit to improve where they are perhaps behind the

curve. The information is shared online so that the consumer can view the sustainability evaluation and goals, striving to comply with all social and environmental regulations (if not already fully compliant) and working constantly to improve their ranching practices (often receiving help and support to do so). The first phase is a pilot project involving two ranch corridors in the Mexican borderlands. *Pilot site 1 – Cuenca Los Ojos, Sonora. A* Mexican non-profit organization which, through a long slow process of restoration, has dramatically improved the vegetation of 7 ranches (42,000 hectares). *Pilot site 2 – Serranías del Burro, Coahuila.* A coalition of ranchers with a long history of conservation and careful management using Savory´s "Holistic Management" framework in 5 ranches covering 37,000 hectares. Leaders and technicians from the Brazilian platform have come together with local ranchers and representatives and field staff from Fondo Mexicano para la Conservation de la Naturaleza AC, and the Botanical Research Institute of Texas, to adapt the program to Northern Mexico. The team spent time together in Brazil reviewing the procedures, and then the platform was translated into Spanish and adapted for Mexican laws and ecosystems. Comprehensive site visits included water monitoring, facilities inspections, observations of management practices, restoration efforts, water management, and biodiversity conservation efforts. It is hoped that the pilot program will quickly offer an irresistible network for all ranchers wanting to advance their readiness to supply high quality products for the 21st century sustainable markets.

HOW TRANSDISCIPLINARY BIODIVERSITY STUDIES CAN CONTRIBUTE TO INFORMED LAND MANAGEMENT.

Sula Vanderplank*

BRIT, Ft. Worth, TX

Many individual species are important conservation targets, but studied in a vacuum, without attention to other species with which they coexist and interact, little is done to ensure the long-term viability of their populations. Rarely is the true wealth of plants, birds, invertebrates, reptiles, amphibians and small mammals that inhabit a ranch demonstrated. At the Botanical Research Institute of Texas (BRIT), we participate in various transdisciplinary field projects that link plants and animals, offering a more holistic view of the landscape to inform development, management and conservation. In these partnerships, BRIT serves in two different capacities: 1) as a botanical authority providing plant identification and habitat descriptions for wildlife studies (e.g., contributing habitat data to studies uncovering populations of previously presumed extinct small mammals; and 2) as part of the botanical team that learns from taxonomic experts in other fields about the suite of faunal species using the habitats that plants provide (e.g., identifying areas of highest fragility and concern using layered information from various disciplines following biodiversity inventories). Results of recent research collaborations will be presented from binational transdisciplinary expeditions to the Baja California Peninsula, Mexico. Collecting detailed biodiversity data for managed land is strongly recommended to assist in the identification of unique habitats that can be easy to overlook, and assessments of habitat quality. They also provide extensive baseline data from which change over time can be monitored in accordance with the interests of the land manager. During these transdisciplinary expeditions we learned that while some species are very sensitive to grazing (e.g., the Sierra San Pedro Martír vole); other very rare species seem to actively favor disturbed ranchland (e.g., subspecies of the round tailed ground squirrel). With this information, the land managers can make selective changes to improve wildlife conservation and rangeland health.

PLANT AND PLANT COMMUNITY RESPONSES TO THE TIMING, FREQUENCY, INTENSITY, AND DISTRIBUTION OF GRAZING.

Walter Schacht*

University of Nebraska-Lincoln, Lincoln, NE

Grazing strategy design and follow-up management decisions generally are based on timing, frequency, and intensity of grazing and related plant and plant community responses. On private rangelands, high beef prices, increased grazingland values, and less grazingland because of grassland conversion to cropland are driving demands for increased harvest efficiency of forage plants on range and pasture. These drivers along with associated government programs (e.g., Environmental Quality Incentives Program) lead to more management-intensive practices, including fencing and water development and smaller pasture size, with the objective of improving grazing distribution and harvest efficiency. With this, there is further sophistication of grazing strategies used by practitioners to achieve their more demanding objectives by integrating timing, frequency, and intensity of grazing. Matching length of grazing period with season of grazing and changing stocking density by plant stage of growth and ecological site are examples of strategies used by ranchers to most efficiently achieve their objectives. Research at UNL's Barta Brothers Ranch and surrounding private ranches has shown that properly-timed short grazing periods improve grazing distribution and that timing of implementation of ultrahigh stocking densities relative to plant stage of growth significantly affects harvest efficiency. Long-term, plant community response to management-intensive grazing strategies on diverse grazinglands has not been closely documented although plant communities appear to be either unaffected or simplified depending on the spatial and temporal distribution of grazing practices. The improved grazing distribution and harvest efficiency also are hypothesized to increase rate and efficiency of nutrient cycling on grazinglands. We are mid-term in modeling the litter and dung-soil continuum on grazinglands managed at different intensity levels. Nutrient cycling responses to grazing practices are critical in driving the long-term response of grazingland plant communities to management.

CURRENT SITUATION, AND CHALLENGES OF CATTLE/WIDLIFE OPERATIONS IN NORTHERN MEXICO.

Gabriel Serna-Aguilar*

Asociacion Nacional de Ganaderos Diversificados y Criadores de Fauna, Nuevo Laredo, Mexico

As a result of the Mexican revolution private ownership of land was limited to the amount of acreage to graze 500 heads. In the north east México, about 30 acres of land are needed to maintain an animal and largest cattle ranch should be no more than 6,000 hectares. Increasing the ranch carrying capacity by managing brush and establishing buffelgrass pastures was every rancher's dream in the 1970's and 1980's. Most of those fields are back to brush because ranchers have no resources to maintain buffelgrass pastures and there is no government support for that. Back in those days, wildlife was a problem, hunting was done mostly by friends, that had the privilege to own a rifle, and those were doing a favor to ranch owners by controlling the wildlife that consumed the forage for cattle. By the mid 1980's sport hunters were more common, and the need of a suitable habitat stopped ranchers to

establish more buffelgrass and provided ranchers with the opportunity to harvest the wildlife complementing the ranch income with no much more effort. Tamaulipas brush country started to grow again and hunting is classified as a farm activity. These bring more government support programs and less tax. We at ANGADI, have been working on bringing in new technology to the ranchers for the last 28 years; but we are still far to accomplish our objectives. We have worked to create, and change the laws to be adequate for the new way to do ranching; with government officers to make them understand wildlife can be harvested to make money out of it, to keep ranches operational with the media showing violence in Mexico; permanent educational programs for ranchers to become more professional, business orientated. The new goal is planned grazing to promote better quality native grasses, and create a carbon credit market.

AGRO-ECOLOGICAL SITE DESCRIPTIONS FOR SOIL POTENTIAL AND SOIL HEALTH ASSESSMENT.

Skye Wills*[1], Diane Stott[2]

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Soil survey organizes the landscape into units with common soil properties, characteristics and classification. Soil survey units can be used to predict soil behavior and thus are useful for making management decisions and evaluating soil change. Traditionally, in the U.S., soil survey mapping concepts have been developed with the dominant use of the landscape in mind. Current enhancement of soil survey includes documenting dynamic soil properties and soil change due to ecosystem management as well as linking soil components phases to ecological sites. Ecological sites are a concept used to describe 'kinds of land' that have common potential kinds and amounts of vegetation and characteristic response to disturbance. Ecological site concepts have proven extremely useful for categorizing and managing native and naturalized systems. However, in intensively managed (agronomic) systems, inputs (e.g. energy, fertilizer, irrigation water) can confound and homogenize vegetation indicators often used to describe ecological states. Therefore, we propose expanding the notions of state and transition models, such that they can be differentiated based upon levels of soil function (indicated by dynamic soil properties) that occur as a result of the management (disturbance). The proposed model can be used as an organizational framework to provide information about both reference conditions and alternative management systems soil functions. The model provides a means of collecting and organizing information about soil potential (highest level of function as indicated by dynamic soil properties) for use in soil health and resource assessment. The model will be tested in an area of Northern Indiana with little native or naturalized vegetation. A matrix will be constructed of all possible management combinations (crop rotation x tillage) and systems will be generalized based on tiers of soil health and dynamic soil properties across decreasing spatial scales and increasing intensity. We expect this information to be conveyed through 'Agro-ecological Site Descriptions' that supplement the information currently available through Ecological Site Descriptions.

OPPORTUNITIES FOR DEVELOPING LARGE SCALE NATIVE SEED MARKETS IN SOUTH TEXAS AS A RESULT OF OIL AND GAS PRODUCTION.

Dean Williams*

Douglass King Seed Company, San Antonio, TX

Historically, South Texas oil and gas exploration and production stands as one of the most dominate industries reshaping the economy and land use in the region. The economic impact is obvious, but the opportunities and challenge for companies and individuals are possibly unexpected or under estimated. This is the case with seed of adapted native species needed for restoration as a result of the Eagle Ford Shale development. In 2009 Douglass King Company, in collaboration with Caesar Kleberg Wildlife Institute, STN and the E. "Kika" de la Garza Plant Material Center began with the main focus of producing germplasm releases of South Texas adapted native grasses. These species had all but been forgotten, were not available or available in very limited amounts from the seed industry. This primary emphasis was to satisfy the projects original mission set forth in 2000 by a group of landowners as well as public and private stakeholders looking for a native seed for restoration and reclamation. At the onset of the project, little was heard or known of the Eagle Ford Shale, but that would change by 2008.Today many South Texas native seeds are available in commercial quantities as a result of the foresight and commitment of those involved. But this segment of the seed industry would not have advanced as rapidly without the restoration need and income created by the Eagle Ford Shale discovery.

RESPONSE FROM USDA CLIMATE HUBS - HOW CAN WE IMPROVE THE USE OF THIS INFORMATION?

Kris Havstad*

USDA Agricultural Research Service, Las Cruces, NM

Give overview of Climate Hub reaction

CAN WE SLOW BRUSH ENCROACHMENT IN THE SOUTHERN GREAT PLAINS? CAUSES AND POSSIBLE SOLUTIONS.

James Ansley*

Texas A&M AgriLife Research, Vernon, TX

Much of the southern Great Plains grasslands and rangelands have become dominated by woody plants ("brush") such as mesquite (*Prosopis*) and juniper (*Juniperus*) in the last 100 years. This vegetation shift has become so pervasive that brush threatens grass-dependent livestock production and grassland-dependent plant and wildlife species. Concurrently, different wildlife species and different income sources such as recreational hunting for shrub-dependent wildlife have developed that further threaten the impetus for restoration of grassland function. Brush encroachment has increased as a result of numerous factors, including increased seed distribution via livestock consumption and fecal deposition of viable seeds. In addition, livestock grazing practices have simultaneously limited the competitive ability of grasses against emerging brush seedlings and reduced frequency of natural fires that depend on grass as fuel. The increase in atmospheric CO2 concentrations may also have a significant impact on brush and grass competitive relationships in favor of brush. This trajectory will continue without anthropogenic brush management intervention. The re-introduction of fire via prescribed fires may play a role, but fire has severe limitations related to frequency and precision of application, as well as desired

effect on brush. Many resprouting shrubs like mesquite and redberry juniper are only temporarily suppressed by fire. In addition, the frequency and intensity of fire required to mimic pre-settlement fire regimes that may have limited brush invasion may not be possible in many rangeland areas, especially as human population growth into rural areas increases. This paper will summarize and prioritize the causes of brush encroachment and point to possible management solutions that offer the most sustainable opportunity to achieve agricultural production, recreation and ecological restoration goals on brush-dominated rangelands.

PRESCRIBED FIRE: FRIEND OR FOE?

Urs Kreuter*

Texas A&M University, College Station, TX

Paradoxically, perceptions by land managers and policy makers that using prescribed fire is risky business because it can lead to loss of life and property has contributed to increasingly destructive wildfire in the western USA. Such perceptions are often erroneously driven by sensationalized media coverage of the destructive nature of wildfires. However, recognition that decades of fuel accumulation under fire suppression policies are resulting in more destructive wildlife has led to calls for the use of controlled fire to reduce brush encroachment and accumulated fuel loads. Much of the discussion has focused on national forests but the use of prescribed fire it is equally relevant for maintaining healthy rangelands on private land. Recent studies have found that liability concern is a major reason for landowner reluctance to use prescribed fire. Such concerns are driven by a state's legal statues governing the use of prescribed fire and by a lack of knowledge, labor and equipment to apply fire safely. Significantly more hectares were burned in counties with gross negligence liability standards than in those with simple negligence standards; this suggests the need to change simple negligence standards to increase the use of prescribed fire. Other studies found that landowner attitudes towards the use of prescribed fire are strongly influenced by perceived support from family members and neighbors in the use of this management tool. Prescribed burning associations have helped change attitudes about prescribed fire by reducing landowner concerns over liability and lack of skills, labor and equipment to apply fire safely. This has led to widespread increase in the use of fire by landowners in the Southern Great Plains since 1997. Current research is exploring the interaction between the ongoing **social and regulatory barriers to implementation of prescribed fire** on private land. Results of this research are provided.

UNDERSTANDING FIRE EFFECTS: ABOVE AND BELOWGROUND PERSPECTIVES.

Morgan Russell*

Texas A&M AgriLife Extension, San Angelo, TX

The overall effects of fire on ecosystems are complex and variable, ranging from the reduction or elimination of aboveground biomass to impacts on belowground physical, chemical and microbial mediated processes. Many producers utilize prescribed burning in order to decrease woody plant encroachment, increase rangeland condition, and improve overall ecological site resiliency. However,

some land managers are inherently focused on the aboveground and immediate effects of fire, often times overlooking the belowground and long-term effects of fire. As a result, prescribed burning in Texas and many other states face an uncertain future. Rapid increases in population and increased “urbanization” of rangeland, air quality concerns, lengthy burn bans, and growing amount of absentee landowners will also make the implementation and understanding of fire even more difficult in the future. Therefore, application of the latest scientific advances that revolve around belowground and aboveground assessments of fire effects will increase overall understanding of both direct and indirect effects further influencing the implementation of prescribed burning. Increased knowledge of fire on rangelands will also stimulate a greater appreciation for the need and application of safe and effective fire and ignite a fire-culture that was once brought to this area centuries ago. Greater understanding of fire effects will benefit landowners looking to not only utilize prescribed burning as a rangeland management tool, but to also facilitate recovery efforts following a wildfire. Many producers understand the bigger role fire plays on rangelands and will share management strategies based off of sound scientific practices used to facilitate the use of fire.

SCIENTIFICALLY SOUND AND SUCCESSFUL GRAZING STRATEGIES - FORGET GRAZING "SYSTEMS".

Tim J. Steffens*

West Texas A&M Univ and Texas AgriLife Extension, Canyon, TX

;Scientists have examined the effects of differential defoliation among rangeland plants at various spatial and temporal scales since the Society was founded. Early efforts examined effects of defoliation on root dynamics and non-structural carbohydrates of individual plants and how different levels of defoliation among neighboring plants affected competitive relations among plants. As science progressed and methods to measure animal grazing patterns and plant responses were refined, some assumptions about plant responses to defoliation and their importance to plant health and community dynamics were modified. We learned about the effects of defoliation and animal selectivity at larger scales that affect watershed function. We also learned more about how animals utilize landscapes, the plants they choose to eat in chosen areas, and how these behaviors can be managed. The scientific evidence does not show that changing grazing patterns using rotational movement of animals across a landscape has no advantages over continuous grazing. Instead, it shows that grazing “systems” that do not correctly change how animals use plants and landscapes or do not correctly adjust to changes in plant growth, relative palatability, and animal selectivity are likely to be no more successful than continuous grazing. However, there are at least ten scientifically-based guidelines for strategic, adaptive management of grazing for desired goals. Every ranch has unique goals, resources, constraints and natural ranges in environmental variability requiring a context specific, adaptive management strategy. By using these insights to correctly adapt management to changing conditions, scientifically sound strategies can be implemented that help land managers regenerate landscapes, improve livestock performance and profitability.

STRATEGIC GRAZING MANAGEMENT DISTRIBUTES UTILIZATION ACROSS COMPLEX, MOUNTAINOUS LANDSCAPES.

Matt Barnes*

Shining Horizons Land Management, LLC, Bozeman, MT

Strategic grazing management improved the spatial distribution of utilization on a complex, mountainous Colorado ranch—using shorter grazing periods, higher stocking density, and smaller paddocks than the extensive management practiced previously on the ranch and currently on many ranches. Cattle regularly grazed steep mountainsides and plants often considered unpalatable, without damaging riparian areas, at moderate overall utilization. Monitoring from 1997-2011 showed increased plant and litter cover, and decreased bare ground, while the stocking rate averaged about 50% higher than under previous seasonlong grazing. This supports recent experimental evidence that multiple-paddock grazing can improve grazing distribution and thus grazing capacity. Distribution of grazing animals can become more even by creating smaller paddocks that collectively include areas that were previously neglected or ignored. Rather than stock all small paddocks simultaneously for a long time, it is far simpler to amalgamate stock into one large herd that moves from one small paddock to the next in a cycle that covers the entire ranch. There are ecological benefits to smoothing out the extremes of overgrazing and under-utilization that occur in large, conservatively stocked paddocks, and production benefits from the increased amount of forage made accessible to livestock by using many smaller paddocks. Collectively, grazing studies and on-the-ground experience provide evidence for widely applicable guidelines for ecological process-based management to achieve ecological and economic goals by manipulating grazing intensity, distribution across time and space, the diversity of plants available to grazing animals, and animals' selection thereof. Effective management of these grazing parameters depends primarily on four sets of variables: (1) stocking rate, both for a grazing period and for the grazing season or year; (2) timing, frequency, and duration of grazing and recovery periods; (3) spatial distribution of grazing; and (4) diversity of plants available and selection of those plants by grazing animals.

BURNING ON THE MCFADDIN RANCH: UTILIZING NEW TECHNOLOGIES.

Brett Huegele*

McFadden Ranch, Victoria, TX

McFaddin Ranch is a fifth generation ranch operating in Victoria County in the coastal prairies and marshes of Texas. The ranch has utilized prescribed fire for many years and is a leader in using new technology in getting prescribed fire on the landscape. They are one of few, if there are any others, utilizing drone technology as they burn.

KILLING TREES AND MAINTAINING PRAIRIE FOR LESSER PRAIRIE-CHICKENS THROUGH PATCH-BURN GRAZING.

Jonathan Lautenbach*[1], Joseph Lautenbach[2], David Haukos[1]

[1]Kansas State University, Manhattan, KS, [2]Sault Ste. Marie Tribe of Chippewa Indians, Sault Ste., MI

The lesser prairie-chicken is a species of prairie-grouse that has experienced a dramatic population decline during the past two decades. Several reasons have been cited for these recent declines including invasive tree and shrub encroachment on native prairie as well as the loss of natural ecological drivers, including fire. We evaluated the response of lesser prairie-chicken space use and nest site selection in relation to tree encroachment. We found that lesser prairie-chickens utilized areas with less than 2 trees per hectare more frequently than areas with greater than 2 trees per hectare. Additionally we did not detect any lesser prairie-chicken nests in areas with greater than 2 trees per hectare. One way of controlling trees is through the use of prescribed fire. Little is known about how prescribed fire impacts lesser prairie-chicken habitat and space use. We measured vegetation characteristics across a landscape modified by fire and grazing in a patch-burn grazing system to assess the impacts of prescribed fire on lesser prairie-chicken habitat. We also measured vegetation characteristics at lesser prairie-chicken nest sites and paired random locations. We found that patches greater-than-2-years post-fire had 2x taller vegetation than year-of-fire patches. In addition, year-of-fire patches had the greatest bare ground and litter whereas patches greater-than-2-years post-fire had the most grass cover and the least bare ground. Lesser prairie-chicken nesting locations had similar vegetation height and structure to that of patches that were greater-than-2-years post-fire. Nest sites had taller vegetation, greater grass cover, and less bare ground cover than paired random locations. Our findings show that patch-burn grazing helps maintain lesser prairie-chickens nesting habitat and therefore, may be a useful tool for controlling tree encroachment.

MANAGEMENT AND SCIENCE IN COMPLEX SYSTEMS.

Grady Grissom*

Rancho Largo Cattle Co., Fowler, CO

A case study at Rancho Largo Cattle Company (RLCC) illustrates how complexity generally makes “scientific management systems” fail. At RLCC goal-driven adaptive management based on scientific studies of specific ecological processes lead to improved economic returns. Improved returns derived from improved ecological conditions. The RLCC case study shows the importance of “kinked” graphical relationships in complex systems for producers and scientists. These V-shaped or S-shaped graphs serve as road maps for producers since at inflection points a small change of a management variable can give significant changes of production variables. The kinked variable relationships in economic and ecological systems require producers to adapt scientific data to their specific operations. Specific goals are essential to drive effective adaptive management since they focus producers on ecological processes rather than management methods. Adaptive management knowledge is not rigorous at the micro-scale. Producers rely on inductive reasoning without variable controls; hence, conclusions about causality are suspect for individual management trials. However, every management decision is a “trial” and managers are forced to make hundreds of decisions a month. Hence, producers are positioned to find the kinks in variable relationships. Macro-scale management knowledge, where multiple producers over multiple years find consistent results is invaluable in understanding complex systems.

COLLABORATIVE ADAPTIVE MANAGEMENT.

Craig Allen*[1], David Angeler[2], Joseph Foutaine[1], Ahjond Garmestani[3], Hart Noelle[1], Kevin L. Pope[1], Dirac Twidwell[4]

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Adaptive management is an approach to management that emphasizes structured learning through decision making based upon the realities that knowledge is incomplete, much of what we think we know is actually wrong, and managers and policymakers must act despite uncertainty regarding best management and management outcomes. AM requires iterative decisions based on information resulting from management and serves to build knowledge and improve management over time in a goal-oriented and structured process. Natural resource management is frequently highly uncertain; ecosystem managers can make better decisions in the future if they can learn. Although AM may be "common sense", there continues to be confusion regarding what actually constitutes AM. This misunderstanding is largely based upon the belief that AM is what management has always been, trial-and-error attempts to improve management outcomes. But unlike a trial-and-error approach, AM has explicit structure, including a careful description of objectives, identification of alternative management approaches, identification of hypotheses of problem causation, prediction of the consequences of implementing management alternatives, procedures for collection and analysis of monitoring data, and a mechanism for updating the management approach as learning occurs. Rangeland management in particular shows promise for application of AM, having a tradition of modeling system dynamics (e.g. state-and-transition models), identifiable spatial management units (e.g., pastures), clear management objectives (e.g., maintain forage production), and reducible uncertainties related to management impacts. We present the techniques and challenges of AM informed with two examples from rangeland ecosystems.

POPULATIONS DENSITY OF ELK: EFFECTS ON LONG TERM VEGETATION DYNAMICS.

Kelley Stewart*

University of Nevada, Reno, NV

Author has choosen not to submit an abstract - he is presenting during the symposium

RESOURCES FOR GETTING FIRE ON THE LAND.

Jeff Goodwin*

NRCS, Temple, TX

Fire on the range landscape is one of the single most important ecological processes affecting rangeland plant community dynamics. The proper application of prescribed fire has long been suppressed in the U.S. largely because of its public perception and confusion with the negative effects of wildfire. However over the past several years many organizations have been bringing fire back on the landscape with specific ecological objectives. There are opportunities for landowners to attain assistance with

prescribed fire implementation and planning on their property. This presentation will discuss planning and implementation opportunities available to private landowners from private consultants, prescribed burn associations to state and federal agencies.

GETTING FIRE ON THE GROUND. GARNERING SUPPORT FROM PRESCRIBED BURN ASSOCIATIONS, NON-GOVERNMENT ORGANIZATIONS, AND YOUR NEIGHBORS.

Kirk Feuerbacher*

The Texas Chapter of The Nature Conservancy, Victoria, TX

Fire, as a naturally occurring disturbance on the landscape, can occur wherever there is vegetation and conducive climatic conditions. Fire produces unique effects that are beneficial to the native flora and fauna that cannot be reproduced through grazing, mechanical treatment, or herbicide application. Prescribed fire can be used safely as a viable tool at a smaller scale to manage rangelands. To be successful, it is important to consider all the economic, social, spatial and physical attributes of the land and the surrounding area. Applying prescribed fire requires planning, preparation, and implementation. Planning and preparation may take a considerable amount of time. Initially you have to determine your objective, formulate the prescription to meet the objective, manage for fuel loading, and establish a burn unit with defensible barriers. There are rules that you must follow that are regulated by state and federal law. You must be covered for liability. There are entities that can help and hinder your implementation. Some beneficial resources include local, state and federal government agencies, prescribed burn associations, non-government organizations and your neighbors. These are people with knowledge, experience, and equipment who can help you be safe, successful, and limit your risk of liability. Why would these people want to help you? So that fire can continue to be used as a management tool on the landscape. Because the use of prescribed fire can offset the risk of wildfire by reducing fuel loads when conditions are less extreme. Because the use of fire as an incorporated tool means that sound management is occurring on the landscape.

MOLECULAR MARKERS FOR RANGELAND WILDLIFE.

Melanie Murphy*, Beth A. Fitzpatrick, Charlotte Gabrielsen

University of Wyoming, Laramie, WY

Molecular tools are becoming commonly available and are frequently applied in rangeland management. These applications of molecular techniques are increasing due to the development of new technology, cross-training of professionals, and reduction in laboratory costs. Molecular tools can be very effectively applied to meet production goals, address rangeland assessment, monitor wildlife populations, develop landscape-level planning tools, and inform adaptive management. In addition, these methods can be used in rangeland assessment to identify presence of cryptic species and quantify genetic diversity within a species. Wildlife species of concern can be monitored for presence, genetic diversity, and movement within a management area. Ability of wildlife to move through a managed landscape can be difficult to assess. Genetic connectivity data can be applied on a landscape level to evaluate ability of species to move through the current landscape and evaluate potential future

landscapes under alternative management plans. In our workshop, we will give a brief primer on population genetics and molecular markers, methods for establishing species presence including environmental DNA, assessing genetic diversity, quantifying gene flow and finally, landscape genetics. Throughout the workshop, we will use examples from rangeland systems and address how these data can be applied to management questions. Participants will work through hands-on examples to help understand molecular applications (no computers or previous skills required). Our goal is for workshop attendees to leave with a better understanding of relevant molecular methods, potential applications to address participant needs, and how to obtain high quality data. Overall Workshop Schedule- 8:00 What is DNA? (Basic genetics refresher, Population genetics 101, Overview of molecular tools available); 8:30 Basics of DNA data (activity) (Gel examples, Microsatellites, Sequence data); 9:00 Matching markers to questions (discussion) (There are lots of approaches, what data do I need?; Pros and cons of different data); 9:30 Establishing species presence (What is eDNA? (water, soil, other environmental samples); Does it work?; Best practices; Example applications; What questions to ask about a dataset); 10:00 BREAK (10:00-10:30); 10:30 Working with eDNA data (activity) (Designing and validating a test; Detectability example); 11:15 How can I use these methods? (Break-out groups to brainstorm ideas for applications; Time for large group discussion); 11:40 LUNCH BREAK (11:40-1:00); 1:00 Using genetic diversity (Heterozygosity, Allelic diversity, Effective population size, Example applications); 1:20 How is genetic diversity created? (activity) (Simulate different conditions; Calculate measures of allelic diversity (Heterozygosity, number of alleles, etc.)); 1:50 Measure gene flow (What is gene flow?; Measuring gene flow); 2:10 Measuring gene flow (activity part 2) (Simulate gene flow; Calculate genetic distances (Fst, Dps); Compare results from two simulations; Discuss major take-home points); 2:40 BREAK (2:40-3:10); 3:10 Relating genetic patters to landscape condition (What is landscape genetics?; How does it work?; How can it be used?); 3:40 Estimating connectivity in relation to landscape condition (activity) (Relating gene flow data to landscapes; Testing alternative hypotheses with data); 4:10 How can I use molecular methods? Time for discussion.

REVIEW OF UAS TECHNOLOGY FOR PHOTOGRAMMETRY AND REMOTE SENSING APPLICATIONS IN RESOURCE MONITORING.

Michael Starek*[1], Jake Berryhill[2]

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Unmanned aircraft systems (UAS), or simply drones, comprise a diverse array of technology consisting of platforms, navigation control, and sensors. Researchers identified the potential of UAS-sourced imagery more than thirty years ago; however, it has only been recently that UAS has evolved from a niche area into a practical surveying tool for wide spread application. By integrating off-the-shelf, low-cost sensors with sophisticated computer vision algorithms, robotics and geomatics engineering, UAS are transforming traditional methods of photogrammetry and remote sensing. The results are image products at hyper spatial resolutions (e.g. sub-cm) with high geodetic fidelity generated from cameras costing a few hundred dollars or less. The flexibility and capability provided by UAS to acquire geospatial data (2D and 3D) and spectral information at local to regional scales has revolutionary implications for resource monitoring. This presentation will provide an overview on the current state-of-the-art in UAS technology for photogrammetry and remote sensing. Recent developments in platforms, sensing, and

data processing will be presented with emphasis on small UAS (< 55 lbs) for resource monitoring applications. Example data products from a UAS photogrammetric survey of Welder Wildlife Refuge in South Texas will also be presented.

MOBILE SENSING SYSTEMS FOR FORAGE EVALUATION AND MANAGEMENT.

Joshua Pittman*

Noble Foundation, Ardmore, OK

Application of technological advances for grazing management have become prevalent in recent years. Developments in sensor technology and GIS systems have allowed for a more accessible set of options for researchers and producers as a function of both cost and availability. The combination of mobile sensing systems and GIS allow for a scenario whereas rapid data collection is possible and spatial projection/ presentation of these data can be used as visualization tools for decision making. Additionally, distinct parameter estimations can also be derived from the sensing system data and used as inputs for calculation of stocking rates or adjustments. Currently there are efforts being pursued at the Samuel Roberts Noble Foundation to employ mobile sensing systems on a number of forage species. Four years of sensor research have been completed on bermudagrass [*Cynodon dactylon* (L.) Pers.], tall fescue (*Festuca arundinacea* Schreb.), wheat (*Triticum aestivum* L.) and alfalfa (*Medicago sativa* L.). Both crude protein and live standing biomass (estimated on a dry weight basis), have been the main emphasis of the work done. Bermudagrass biomass and crude protein, and wheat biomass and crude protein can be predicted using the mobile sensing system developed by the Noble Foundation to 78%, 85%, 74%, and 62% accuracy respectively. Alfalfa biomass can be predicted to 64% accuracy and tall fescue crude protein to 83% accuracy. Use of these types of systems for evaluation of grazing systems will allow for rapid accurate capture of information and can enable heightened efficiency in improved pasture and rangeland management scenarios

REMOTE SENSING TECHNOLOGY AND UNMANNED AERIAL SYSTEMS (UAS) FOR THE PRECISION MANAGEMENT OF CROPS AND NATURAL RESOURCES.

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Crops are often unable to express their full genetic potential due to unfavorable environmental conditions. Timely identification of both biotic and abiotic sources of crop stress (e.g. drought, high temperature, and insect & disease pressure) has the potential to increase crop yields and decrease production costs by improving water, fertilizer, and pesticide management. Unmanned Aerial Systems (UAS) when properly equipped with remote sensors enable the acquisition of agronomic data at significantly higher spatial and temporal resolutions at much lower cost when compared to other traditional airborne and satellite platforms. Passive (multispectral and thermal) and active sensors (LiDAR) can collect valuable information on crop growth, development, and overall plant health. Crop canopy temperature is a simple measurement that has long been associated with plant water status.

NDVI from multispectral data is also known to provide useful information on crop growth rates, canopy cover, and ultimately, crop photosynthetic efficiency. Measurements from the remote sensors are then integrated with position (recorded from GPS) and orientation (measured from Inertial Measurement Unit) of the UAS platform to generate seamless geospatial data products such as orthomosaic and Digital Surface Model (DSM). These geospatial data products can be used to 1) provide visual clues to agricultural scientists on the overall crop status, 2) monitor growth patterns at individual crop level, and 3) estimate above ground biomass throughout the crop's life cycle. The added capability to quantify crop stress values at any point during the growing season is a powerful tool for both management and screening purposes. Currently, the acquisition of temporal and spatial biomass data is performed by strenuous, destructive, and labor-intensive hand sampling practices. Our objective at Texas A&M AgriLife is to develop an UAS remote sensing data platform and processing/visualization tool that will enable the discovery and quantification of genotype, phenotype, and environment interactions.

USE OF SHARP-TAILED GROUSE LEKS BY GRASSLAND BIRD SPECIES IN THE NEBRASKA SANDHILLS.

Ethan Freese*[1], Maggi Sliwinski[2], Walter Schacht[2], Larkin Powell[2]

[1]University of Nebraska - Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, Lincoln, NE

Sharp-tailed grouse use leks to find mates during their breeding season. The leks usually have short vegetation, which can be achieved and maintained through management decisions such as grazing or haying. While the benefits to grouse are obvious, the influence of leks on other bird species has not been documented. We completed a field study to determine if leks contributed to habitat heterogeneity, and if breeding bird abundance was influenced by the presence of leks. The leks in this study were located in the Sandhills south of Valentine, Nebraska. Each lek was paired with a randomly-located off-lek site. At each lek and off-lek site habitat data were recorded in May and July at a distance of 0, 25, 50, 75, and 100 m from the center point of each lek and random site. Birds were surveyed four times at each point in June 2015. Results showed that structure measures were different at the 0-m point on leks and off-lek sites, but there were no differences in vegetation structure between sites at the 25-100 m distances. The only bird species influenced by leks were brown-headed cowbirds and mourning doves. Both were three times more common at off-lek sites. Other bird species were not influenced by leks likely because of small lek size. This study will help give land managers a better understanding of the use of leks by grassland birds in the Nebraska Sandhills, and we hope will serve as a springboard for further research on the function of leks.

THE EFFECT OF SOIL TYPE ON THE GERMINATION OF BOTHRIOCHLOA ISCHAEMUM, AN OLD WORLD BLUESTEM.

Corban Hemphill*

Oklahoma State University, Stillwater, OK

Old World Bluestem (OWB) is native to Europe and Asia and was widely planted historically in the southern United States to prevent soil erosion and to serve as forage for livestock (Shaw 2012). However, its invasive nature allows it to frequently invade an area, displacing more desirable species of

native plants (Hickman, et al., 2004). This invasion decreases biodiversity as the native range is replaced with a monoculture of OWB. OWB does not provide adequate nesting habitat for many grassland species of birds, including northern bobwhite (Colinus virginianus) and other upland game birds, and is only fair forage for livestock (Hatch and Pluhar 1993). Therefore, it is often necessary for land managers to control the invasion of OWB. Seed production of OWB is an important control point for the OWB invasion. If OWB stands within particular soil types/ecological sites were found to produce more germinable seed than other sites, land managers could target their control practices on these localized areas, thus decreasing the cost of control. Our objective was to assess whether germinable seed production differed in different soil types/ecological sites invaded by Bothriochloa ischaemum, and if there were differences, did soil type/ecological site have an effect.

USE OF MOWING TO INCREASE LIVESTOCK SELECTION OF INVASIVE BOTHRIOCHLOA ISCHAEMUM.

James Craun*, Karen R. Hickman, Eric Duell

Oklahoma State University, Stillwater, OK

Bothriochloa ischaemum (yellow bluestem) is an introduced Old World bluestem commonly planted to Conservation Reserve Program fields or as an alternative livestock hay or forage throughout the southern Great Plains. Research indicates B. ischaemum provides minimal ecosystem services in invaded rangelands. In an effort to reduce B. ischaemum invasion, we implemented a grazing study comparing mowed and non-mowed B. ischaemum and native forages to determine livestock preference of the forages. Three invaded rangeland sites were located at the Stillwater Research Range near Stillwater, OK, USA. At each site 12 B. ischaemum and 12 native forage plots were established; each plot consisted of an exclosure and an open block (4m2 each) to compare the mowing and grazing treatments. In June 2015 leaf length, inflorescence density, and biomass were measured prior to mowing. We then randomly mowed six B. ischaemum and six native forage plots at each site to a height of 5cm. In July, August, and September, leaf length and inflorescence density were measured, and biomass was measured again only in September. Preliminary results suggest grazing with or without mowing reduced leaf length of B. ischaemum proportionally more than the native forage. Grazing with mowing reduced inflorescence density by 37%-77%, whereas grazing without mowing reduced density by 16%-72%. Native forages had minimal reduction in inflorescence density. Biomass has been collected and results will be presented. These results indicate mowing and grazing may an affordable tool in reducing B. ischaemum invasion without hindering native forage production.

EFFECTS OF SEEDING NATIVE VS INTRODUCED SPECIES, RODENT FOOD SUPPLEMENTS, AND ANT MOUND PRESENCE ON VEGETATION ESTABLISHMENT ON THE UTAH TEST AND TRAINING RANGE (UTTR).

Jesse Morris*[1], Bruce A. Roundy[2], Brock McMillan[1], Jace Taylor[1]

[1]Brighan Young University, Provo, UT, [2]Brigham Young University, Provo, UT

Disturbance due to military activity on the Utah Test and Training Range (UTTR) has resulted in invasive annual weed dominance by *Salsola iberica, Kochia scoparia, Kochia hyssopifolia, Halogeton glomeratus,*

and *Bromus tectorum*. These invasive weeds increase the frequency of fire and provide limited support for wildlife. Vegetation restoration is required to improve wildlife habitat on these rangelands. Precipitation on the UTTR (< 200-300 mm/year) is marginal for successful revegetation from direct seeding, especially for native species on these former salt desert shrub communities. Seed predation by rodents and ants could also limit plant establishment. In this randomized block study we measured density of seeded species for both native and introduced seed mixes, and where subplots received supplemental rodent food pellets.. We also measured vegetation cover and density in relation to distance from ant mounds. Preliminary analysis indicates that although seeded native grasses were evident the first year after seeding, introduced grasses had higher density and were associated with lower weed cover.

SAMPLING INTENSITY TO ASSESS PRE-DISTURBANCE VEGETATION COVER AT ENERGY EXTRACTION SITES IN NORTHEAST WYOMING.

Kelsey Welter*, Jeffrey L. Beck

University of Wyoming, Laramie, WY

Accurate and efficient pre-disturbance vegetation assessments are a critical element of successful reclamation of rangelands used for energy development. Correct identification of plant taxa and documentation of plant composition at pre-disturbed sites provides information integral to ensure success of post-disturbance reclamation. In addition, there is disagreement among energy companies on post disturbance conditions because pre-disturbance vegetation assessments dictate standards for density and composition of reclaimed sites. Operators attempt to compensate for variation in vegetation measurements across sites by increasing sampling intensity, which increases monitoring costs. The purpose of my research was to evaluate the amount of Daubenmire cover data that maximizes precision and efficiency (reduced costs) for oil well pad sites. I specifically evaluated cover data collected by Grouse Mountain Environmental Consultants at 10 sites in June 2015 in northeastern Wyoming. To evaluate precision I computed coefficients of variation (CV) for 5, 4, 3, and 2, 100-m transects positioned at pre-determined locations on proposed ≤4 ha well pads. To evaluate efficiency I coupled field costs/transect with CV results to determine adequate sample intensity. My results are important because they provide a realistic way to balance costs and data precision for rangeland monitoring intended to inform reclamation practices.

DROUGHT CONSEQUENCES FOR COW-CALF PRODUCTION IN WYOMING: 2011-2014.

Jessica Windh*[1], John D. Scasta[1], Travis Smith[1], Bob Baumgartner[1], James Hageman[2]

[1]University of Wyoming, Laramie, WY, [2]University of Wyoming, Lingle, WY

Lack of precipitation due to drought conditions has a negative effect on cattle production in regards to lower quantities of forage leading to a decrease in stocking rates. However, actual impacts on livestock performance, including calf growth potential and the subsequent economic impacts, during these time are less understood. In a study from 2011-2014, 869 calves on two University of Wyoming ranches were assessed for weaning weights and gains per day for an adjusted 210 day period. Precipitation during

these years varied from 5.9” to 16.4” and 4.2” to 11.1” at the two ranches. Between the wettest and driest years the difference in weaning weights was up to 99 pounds and in gains per day was up to .47 pounds. At these two ranch locations, it can be predicted that for each inch reduction in precipitation, weaning weights will subsequently be 7 to 14 pounds lower, gains per day will be 0.03 to 0.07 pound lower, and price per head values will be $12 to $27 lower.

A COMPARISON OF TWO METHODS FOR SAMPLING HERBACEOUS COVER: A RICH COUNTY, UT CASE STUDY.

Katherine G. Thomas*[1], Kristin Hulvey[2], Eric Thacker[3]

[1]Brigham Young University Idaho, Rexburg, ID, [2]Utah State University, LOGAN, UT, [3]Utah State University, Logan, UT

Rangelands in the intermountain west provide multiple ecosystem services including sustainable forage for livestock and habitat for sage grouse. One common way to assess changes in the quality of these services is by monitoring changes in the canopy cover of herbaceous species. While many sampling methods now exist, some methods may be more appropriate than others depending on the cover classes measured and composition of the landscape. The purpose of this project is to assess which of two techniques will be more efficient and effective for evaluating herbaceous cover in a sagebrush dominated communities. We evaluated canopy cover of herbaceous species across 50 transects using two different methods, a modified Daubenmire technique and photography-based grid-point intercept (GPI). While Daubenmire estimates are taken in the field, GPI simply requires photos taken along the transect and analysis of these photos is performed via computer, by manually identifying species intersected by a one hundred pixel-grid on each image. Our results suggest that Daubenmire and GPI canopy cover estimates are different, indicating that the methods may not be compatible. The Daubenmire method allowed us to assess herbaceous cover beneath the shrub canopy, while GPI does not allow observers to easily quantify cover in the understory because the photos are taken above shrub canopies, which obstruct a portion of herbaceous cover. Our findings will enable us to evaluate which method is appropriate for sampling herbaceous canopy cover in sagebrush dominated ecosystems.

ASSESSING THE VARIANCE IN STOMATAL SIZE AND FREQUENCY AMONG CYTOTYPES OF POPULUS TREMULOIDES.

Brianne Palmer*

Utah State University, Logan, UT

Populus tremuloides is the most widely distributed broadleaf forest tree in North America. However, aspen are declining rapidly in areas of the Intermountain West. Aspen in this area are prone to experiencing limited moisture and high temperatures. An important aspect of plant physiology when dealing with these stressors is stomatal function. Stomata control the rate of photosynthesis, therefore, the size and frequency of the stomata is likely to influence the survival of the species in this

environment. An unusual feature of aspen is the high frequency of triploidy in the southern portion of its range. Stomatal size and frequency differences between cytotypes have not been assessed in aspen. The purpose of this study is to evaluate the differences in stomatal length and frequency between diploid and triploid aspen in Utah. If stomatal size differences are pronounced between cytotypes, this could be the basis of a rapid field-based test to distinguish cytotypes without laboratory analyses. To test this, I collected leaves from independent clones in Logan Canyon and Fish Lake National Forest in the summers of 2013, 2014, and 2015. Through flow cytometry I determined the ploidy of the trees. Using cellulose acetate impressions of the underside of the leaves I measured the stomatal size and frequency. Based on my preliminary analysis, there is a difference in stomatal size and frequency between clones rather than between cytotypes. Understanding the complexities of the different aspen ploidies is essential in future forest management and prediction future vegetation changes in a changing climate.

PRACTICAL TARGETED APPROACH TO DEVELOPING NATIVE ECOSYSTEMS.

Kelly Fogarty*

SRM, Littleton, CO

A panel discussion to review the ongoing focus by agencies and wildlife and conservation organizations on pollinator habitat and how the subsequent planting and implementation process of such practices will impact supporting ecosystems. Representatives from industry and supporting organizations will lead a series of panel presentations on the topic, followed by questions and further discussion from the audience.

COMPARATIVE ANALYSIS OF REMOTE SENSING VERSUS TRADITIONAL TECHNIQUES FOR MONITORING MACARTNEY ROSE IN TEXAS COASTAL PRAIRIE RANGELANDS.

Michael Bartmess*

Texas A&M University, College Station, TX

This study will attempt to determine if remote sensing analysis of digital imagery collected and maintained by the USDA's National Agriculture Imagery Program (NAIP) is comparatively accurate to traditional line intercept field data collection and analysis methods for monitoring canopy cover of the exotic invasive Macartney Rose (Rosa Bracteata) in the Texas Coastal Prairie. To accomplish this, line intercept data collected in 2012 and 2014 will be compared with remote sensing interpretations of digital imagery from the corresponding year using traditional double sampling statistical analysis. There are two major distinctions between this and previous research on the subject. The first fundamental difference is this study utilizes free, publicly available imagery versus costly custom flights and image processing. The second is that the remote sensing interpretations will be statistically compared with ground data in order to determine a relationship between the two, instead of using a visual comparison of remote sensing output and aerial photographs. Macartney Rose has negative ecological and

economic impacts on rangelands and pastures throughout southeastern Texas. If viable, remote sensing can provide more economical, comprehensive vegetation monitoring information to land managers and owners. This information can potentially assist stakeholders who wish to assess or improve vegetation management practices, leading to improved ecological condition and forage productivity.

MESQUITE SEED DENSITY IN FECAL SAMPLES OF RARAMURI CRIOLLO VS. ANGUS X HEREFORD COWS GRAZING CHIHUAHUAN DESERT RANGELAND.

Tatjana H. Mercado*[1], Andres Cibils[1], Shelemia Nyamuryekunge[1], Rick Estell[2], Alfredo Gonzalez[3]

[1]New Mexico State University, Las Cruces, NM, [2]USDA-ARS Jornada Exp Range, Las Cruces, NM, [3]USDA-ARS Jornada Exp. Range, Las Cruces, NM

This study was part of a larger project investigating breed-related differences in feeding habits of Raramuri Criollo (RC) versus Angus x Hereford (AH) cows. Seed densities in fecal samples collected in July and August 2015 were analyzed to compare presumed mesquite bean consumption of RC and AH cows grazing Chihuahuan Desert rangeland in summer. Two groups of 11 nursing RC or AH cows grazed separately in large adjacent pastures for four weeks. After the first two weeks, groups switched pastures to insure that both breeds were exposed to the same grazing environment. Five cows in each group were fitted with GPS collars configured to log animal location at 10 minute intervals. Weekly rectal fecal samples were collected from all 22 cows. Fecal samples were frozen and later thawed at 40oC. All seeds were recovered, surface sterilized, identified, counted, weighed, and placed in petri dishes at room temperature. Seedless thawed fecal samples were then dried at 60oC for 72 h and weighed. A mixed effects repeated measures analysis of variance was used to determine the influence of breed and pasture on mesquite seed density in fecal samples of RC and AH cows. Mesquite seed density in feces was significantly higher in RC vs. AH cows (Mean ± SEM RC: 0.21 ± 0.01 vs. AH: 0.09 ± 0.03 seeds/g seedless fecal DM; $P = 0.03$). Mesquite seed density in RC fecal samples was similar regardless of pasture grazed ($P=0.32$). Conversely, seed density for AH cows differed significantly among pastures ($P = 0.03$). Despite their apparent higher consumption of mesquite beans, GPS data revealed that RC spent detectably less time ($P \leq 0.05$) in mesquite-dominated plant communities than their AH counterparts. Our preliminary results suggest that during summer months, RC cows included higher amounts of mesquite seed pods in their diet compared to AH counterparts. The fact that AH cows spent more time than their RC counterparts in mesquite-dominated areas suggests that AH possibly seek mesquite shrubs for both forage and shade.

DO INTENSIVELY MANAGED GRAZING SYSTEMS ALTER LIVESTOCK USE OF RIPARIAN AREAS?: INSIGHTS FROM A CASE STUDY IN RICH COUNTY, UTAH.

Ben Davis*

Utah State University, Logan, UT

Livestock grazing is a major land use in the western United States. Riparian areas are an important source of forage and water for cattle. Proper grazing is essential in maintaining riparian function and value. Improper grazing practices can impair riparian function by depletion of riparian vegetation,

trampling streambanks, and overbrowsing of riparian shrubs. Use of grazing deferment and or rest are commonly recommended practices for managing riparian zones. We placed global positioning system (GPS) collars on cattle under time controlled grazing management and a more traditional season long grazing system in Rich County, Utah. The two adjacent grazing systems provided an opportunity for a comparison of the two grazing systems in order to describe the effects of these systems on riparian use by cattle. Resource selection functions were used to estimate the relative importance of various environmental factors on site selection by cattle and the overall differences in cattle use of riparian areas. This work will illustrate how cattle use of riparian areas differ between grazing systems and will provide an important ranch scale assessment of how grazing systems affect livestock distribution.

DEVELOPMENT AND CURRENT EVOLUTION OF RANGELAND STATE AND TRANSITION MODELS: UTILIZING DISTURBANCE RESPONSE GROUPS AND STMS IN LAND MANAGEMENT DECISIONS.

Tamzen Stringham*

University of Nevada Reno, Reno, NV

Land management activities within rangeland settings often occur at scales larger than the individual ecological site scale therefore we have development a method for aggregating ecological sites into groups that respond similarly to management activities or disturbance. The methodology has proven useful for the rapid development of state and transition models (STMs) in addition to the application of models for landscape scale planning purposes. BLM in collaboration with the University of Nevada, Reno and Nevada NRCS has utilized STMs developed through this process to assess multiple fuels treatments and wildfire responses in order to improve future habitat improvement and rehabilitation projects. Additionally, private landowners have recently been incentivized through the Nevada Conservation Credit System to utilize STMs for sage grouse habitat improvement projects. Results from both public and private sector application of STMs for rehabilitation projects will be presented.

IMPACT OF GRAZING AND TRAMPLING ON TWO DIFFERENT RECLAMATION TREATMENTS IN SOUTHERN ARIZONA.

Hannah Farrell*

University of Arizona, Phinoex, AZ

Pipeline construction projects create landscape scale disturbances by stripping away the vegetation and disturbing soils, which can lead to poor native vegetation recovery and opportunities for invasive plant dominance. As part of a designed experiment, we are studying the effects of the reclamation efforts and land management decisions on a 60 mile natural gas pipeline right-of-way in Southern Arizona, which was constructed in summer of 2014. The study quantifies the treatments of drill seeding, grazing exclusion, and trampling exclusion (foot and vehicle trampling) on plant establishment in comparison to undisturbed adjacent land. We use plant species composition and plant density metrics to evaluate the effects of each treatment. This poster presents the progress of plant establishment on the right-of-way approximately one year following reclamation efforts and at the close of the 2015 monsoon season. Our initial results indicate that, while vegetation biomass and density is similar regardless of seed treatment,

less desirable community of species has established without seeds. Additionally, trampling by vehicles, humans, and cattle has an impact on vegetation establishment characteristics. We can draw applicable conclusions from this data about the ability of native plants to propagate from the soil seed bank or adjacent sites, the effectiveness of seeding for controlling invasive plants, and the effects of grazing and trampling on plant establishment.

UTILIZING OUTREACH AND GRAZING TO IMPROVE CONSERVATION AND SOIL HEALTH.

Monti Golla*

National Grazing Lands Coalition, College Station, TX

The National Grazing Lands Coalition (NatGLC) was awarded a Conservation and Innovation Grant with the USDA NRCS in 2014 to conduct outreach/education/demonstration opportunities on how prescribed grazing impacts pasture and range productivity, conservation and soil health. The cornerstone of this project is the use and on-farm demonstration of rainfall simulators to facilitate technology transfer to producer-lead community based organizations of underserved, limited resource and socially disadvantaged groups on a nationwide scope. Hands-on workshops held by our project partners in Texas, Louisiana, South Dakota, South Carolina and New York accompany these demonstrations to enhance assimilation and adoption of grazing land management practices. Our poster presentation at the SRM will showcase these demonstrations with pictures and technical information for conference attendees. Dates and locations of future demonstrations will be listed.

REMOTE SENSING TECHNOLOGY AND UNMANNED AERIAL SYSTEMS (UAS) FOR THE PRECISION MANAGEMENT OF CROPS AND NATURAL RESOURCES.

Juan Landivar*

Texas A&M AgriLife Research, Corpus Christi, TX

Crops are often unable to express their full genetic potential due to unfavorable environmental conditions. Timely identification of both biotic and abiotic sources of crop stress (e.g. drought, high temperature, and insect & disease pressure) has the potential to increase crop yields and decrease production costs by improving water, fertilizer, and pesticide management. Unmanned Aerial Systems (UAS) when properly equipped with remote sensors enable the acquisition of agronomic data at significantly higher spatial and temporal resolutions at much lower cost when compared to other traditional airborne and satellite platforms. Passive (multispectral and thermal) and active sensors (LiDAR) can collect valuable information on crop growth, development, and overall plant health. Crop canopy temperature is a simple measurement that has long been associated with plant water status. NDVI from multispectral data is also known to provide useful information on crop growth rates, canopy cover, and ultimately, crop photosynthetic efficiency. Measurements from the remote sensors are then integrated with position (recorded from GPS) and orientation (measured from Inertial Measurement Unit) of the UAS platform to generate seamless geospatial data products such as orthomosaic and Digital Surface Model (DSM). These geospatial data products can be used to 1) provide visual clues to agricultural scientists on the overall crop status, 2) monitor growth patterns at individual crop level, and

3) estimate above ground biomass throughout the crop's life cycle. The added capability to quantify crop stress values at any point during the growing season is a powerful tool for both management and screening purposes. Currently, the acquisition of temporal and spatial biomass data is performed by strenuous, destructive, and labor-intensive hand sampling practices. Our objective at Texas A&M AgriLife is to develop an UAS remote sensing data platform and processing/visualization tool that will enable the discovery and quantification of genotype, phenotype, and environment interactions.

DETECTING LAND USE HISTORY WITH AERIAL PHOTOGRAPHY IN PLACE OF SATELLITE IMAGERY: CAN ADVANCEMENTS IN REMOTE SENSING TECHNOLOGY ENHANCE GROUND-TRUTHING METHODS?

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Land use decisions are central to the future of how well agriculture and conservation practices mesh. Specifically, assessments on the impacts of conversion from native habitats to crops have been the focus of several studies over the last decade. While presumably measurable, the actual extent of land within a geography that is potentially native (untilled or undisturbed) is impossible to accurately measure using traditional remote sensing technologies such as satellite imagery. We developed a new land use assessment methodology in 2014 for South Dakota and portions of western Minnesota. Unlike other inventories that attempt to capture the current extent of grasslands by utilizing satellite imagery such as National Agricultural Statistics Service (NASS) data, our inventory is unique in that it utilizes Farm Service Agency Common Land Unit (CLU) data overlaid on National Agricultural Imagery Program (NAIP) aerial Imagery as the basis for determining the majority of cropping history in the region. Our final data is made publicly available through the creation and distribution of geodatabase files. The geodatabase identifies all remaining likely 'undisturbed' land tracts, and is the most comprehensive information available in this region. Continual refinement over time will allow for an improved understanding of land use, including future assessments of changes in the status of native habitats. Innovations in remote sensing technologies and data such as Unmanned Aerial Systems (AUS) coupled with high resolution photography or advanced imagery such as Light Detection and Ranging (LiDAR) may serve to facilitate advancements in ground-truthing beyond the current system of physically visiting tracts to verify accuracy of land use history.