

# **ABSTRACTS**

## **2000 SHORTGRASS STEPPE SYMPOSIUM**

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Effects of a nitrogen and competition gradient on the growth of an exotic, invasive annual and a slow-growing native perennial.

Exotic plant invasions are a serious concern for land managers and conservationists. As such, it is important to establish baseline, empirical response data for native and exotic species under different nutrient and competition levels. We examined the response of above and belowground biomass, plant height, and nitrogen tissue concentrations in two different species, *Bromus tectorum* (exotic), and *Bouteloua gracilis* (native), to a gradient in nitrogen and competition. Competition significantly affected aboveground biomass accumulation of both species, although mean separation tests showed that intraspecific competition was the only competition affecting *Bromus*, while the opposite was true of *Bouteloua*. Both species had a significant response to the nitrogen gradient, with *Bromus* having a much stronger response to increasing nitrogen availability than *Bouteloua*, which did not respond to added nitrogen after a certain level.

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McCulley, Rebecca and Indy Burke. Sensitivity of grassland biogeochemical parameters across a naturally occurring precipitation gradient.

The goal of this proposed research is to quantify the pattern of water versus nutrient constraint across the community and climatic gradient spanning the Central Plains. Our central hypothesis is that the mixed grass communities present in the middle of the gradient will be most responsive to changes in growing season precipitation due to lower dominance of either water or nutrient constraints on net primary production (NPP) at these sites. We established five sites across the climatic gradient, and we have begun characterizing nutrient cycling parameters that influence nutrient availability at all sites. We will construct a precipitation manipulation experiment at these sites to determine the ability of these communities to respond (in terms of NPP and nutrient availability) to variation in water availability. We will measure above- and belowground biomass, tissue carbon and nitrogen, *in situ* net nitrogen mineralization, and soil respiration. Our results will contribute to the functional understanding of the biogeochemical processes and controlling parameters of these grassland communities, as well as increase the accuracy of predictions concerning ecosystem response to changing climate.

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Title: Effects of Irrigation and Cultivation on Carbon and Nitrogen in Northeastern Colorado

Abstract: Agricultural management practices influence the amount of carbon stored in the soil. Differences in carbon content between wheat-fallow and native rangeland soils are well documented for the shortgrass steppe. However, effects of irrigated crops on carbon storage is not well studied for this region. I measured the carbon and nitrogen contents of irrigated corn, wheat-fallow, and native rangeland soils in the summer of 1999 in northeastern Colorado. Total carbon, total nitrogen, organic C fractions and POM fractions will be measured in these soils to a depth of 2 meters. In addition, I measured potential C and N mineralization for soils to a depth of 15cm. Future work may involve assessing differences in decomposition rates between irrigated and non-irrigated crops and native rangeland soils.

Interannual differences in abundance of thirteen-lined ground squirrels (*Spermophilus tridecemlineatus*) in Colorado shortgrass steppe

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We live-trapped thirteen-lined ground squirrels (*Spermophilus tridecemlineatus*) on three grassland and three saltbush-dominated sites in June and July 1999 to estimate population densities in representative vegetation types in Shortgrass steppe, and to describe changes in population structure and body weight during their summer active period. We also compared population densities in 1999 to estimates from 1995, the last time the ground squirrel populations were surveyed on the SGS LTER site in north-central Colorado. As in 1995, most squirrels captured in June 1999 were adults; the near absence of juveniles in June 1999 compared to the earlier study suggested that reproduction was delayed this year. Juveniles comprised >70% of individuals captured in both habitats in July 1999, and were especially numerous on grassland sites. However, in contrast to 1995, when squirrels were much more common in saltbush habitats, squirrels were significantly (2 – 3x) more abundant on grassland sites in 1999. The difference in population densities between habitats in 1995 vs. 1999 was unexpected because both years had similarly high early-season precipitation, and presumably, similar vegetation. Moreover, there were no consistent differences in the abundance of arthropod prey between years that could readily explain the differences in squirrel abundance. Additional long-term studies of ecology and population dynamics of thirteen-lined ground squirrels in Shortgrass steppe will be necessary to identify factors that determine patterns of abundance of this critical species over time.

## Trophic Structure of Soil Communities Across a Productivity Gradient

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We studied the effects of productivity on the trophic structure of soil communities along a productivity gradient. Models exhibited a non-linear response to increased productivity resulting in a continuum of trophic structures. Below 10 - 100 g C m<sup>-2</sup> yr<sup>-1</sup>, models were more prone to declines in food chain length and cascades of biomass than those above this range. We surveyed the biota of following soils: McMurdo Dry Valleys, Antarctica (<0.01 g C m<sup>-2</sup> yr<sup>-1</sup>); caverns of Jewel Cave, South Dakota (0.1-10 g C m<sup>-2</sup> yr<sup>-1</sup>); tundra at Toolik Lake, Alaska (30-300 g C m<sup>-2</sup> yr<sup>-1</sup>), saxicolous lichens (< than the grasslands), Colorado, and the shortgrass steppe (SGS), Colorado (300-600 g C m<sup>-2</sup> yr<sup>-1</sup>). Soils from Antarctica and Wind Cave exhibited either trophic cascades, or declines in food chain length from 3 levels (microbes, microbivores, and predators) in the more productive sites to 1 level (microbes only) at the least productive sites. The lichens, tundra and SGS supported food chains of 4 or more levels. Communities form a continuum of trophic structures governed by productivity and the regulation afforded by predators.

## Impacts of managed grazing on mycorrhizae in mountain and prairie ecosystem

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Grazing by native and introduced herbivores may induce changes in the linkages between above- and belowground communities directly through the removal of plant biomass and plant species, or indirectly by altering nutrient pathways in soils. The degree to which these changes occur is dependent on the plant-herbivore assemblages in place the history of grazing that the ecosystem developed under. The plant communities of the North American Shortgrass Steppe are believed to be resistant and resilient to cattle grazing given the history of grazing by large herbivores (bison and antelope) prior to European settlement. Less is known about how cattle grazing might affect sagebrush and grass ecosystems at higher elevations with a different grazing history (antelope, deer, and elk). The objectives of our study were to assess the impact of managed grazing on mycorrhizae within each ecosystem. From 1994 to 1998, we measured the mycorrhizal inoculum potential (MIP) of soils from native grazed and cattle grazed pastures at two mountain sites near Walden, Colorado (North Park Deer Enclosure and Cattle Grazed/Native Grazed) and four manipulated cattle enclosures at the Shortgrass Steppe - LTER. At the mountain sites, the MIP of cattle grazed pasture soils (33.18%) was significantly lower ( $p=0.055$ ) than native grazed pasture soils (40.35%). The MIP of prairie soils did not differ significantly among the cattle grazed and native pastures. Significant ( $p<0.05$ ) year to year variation in MIP was encountered at both mountain and prairie sites. In terms of MIP, prairie soils are resistant to cattle grazing. It appears that the MIP of soils at the mountain sites are more prone to cattle grazing than the prairie sites.

Can schoolyard ecology LTER plots affect student attitudes and career aspirations towards ecology?

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We established a series of Schoolyard LTER demonstration plots on the UNC campus in the summer of 1998 and have arranged to establish plots on the grounds of several schools in the Greeley and Ft. Collins area. How can we maximize the impact of the plots on student attitudes towards science, their understanding of ecology, and their career aspirations? We conducted a preliminary study which found that high school students who were exposed to more science-related informal learning opportunities (such as museum and botanical garden visits, scientific magazines) had higher science attitude scores (~20%) than students with fewer opportunities. Additionally, we found that the quantity of learning opportunities was related to the student's socio-economic status and level of parental education. Based on these preliminary results we developed a survey to focus on the relationship between specific informal learning activities and student attitudes and career aspirations towards ecology. Results from our ecology-oriented survey suggest that students exposed to ecology related activities (i.e., collecting insects and plants) were more aware of conservation issues and career opportunities in biology/ecology related fields. These findings will be used to guide the design of the plots and their use as informal and/or formal education tools.

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Jeanine R. Junell and Beatrice Van Horne. Effects of black-tailed prairie dog (Cynomys ludovicianus) activities on ground-dwelling fauna of the shortgrass steppe.

Black-tailed prairie dogs (Cynomys ludovicianus) modify their habitat by grazing and clipping vegetation and by building mounds and digging burrows. These changes create a patch of habitat that is different from the surrounding grassland, which may in turn affect the activities of other grassland species. Many studies have documented the effects of prairie dogs on vegetation, however, only a few studies have looked at how they affect the fauna of the shortgrass steppe and very few have looked at arthropod species. We chose darkling beetles (Coleoptera: Tenebrionidae) as our focal taxon because they are known to seek shelter in cool micro-habitats, and we believe that they may use prairie dog burrows for shelter and perhaps for over-wintering. In the summers of 1997 and 1998, we conducted pitfall sampling of five prairie-dog towns and five non-town grassland sites in the shortgrass steppe of northeastern Colorado. Although our objective was to collect darkling beetles, other insects and several vertebrate species were captured incidentally. Currently, beetle data has been analyzed for one of our eight sampling dates- late July 1997. Contrary to our hypothesis, tenebrionid beetles were more abundant on off-town sites than on prairie dog towns. Ground beetles (Family Carabidae) were the most abundant family of beetles, yet were not significantly different between towns and off-town sites due to high variation. The only family that was more abundant on prairie dog towns were the leaf beetles (Family Chrysomelidae). Analysis of all sampling dates showed that lesser earless lizards (Holbrookia maculata) and striped chorus frogs (Pseudacris triseriata) were captured more frequently on prairie dog towns than on control sites.

## **Remediation of Nitrate Contaminated Soils Using Vegetable Oil: Soil Column Studies**

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### **ABSTRACT**

Agricultural operations that involve manure can lead to groundwater contamination. Innocuous oils might be used as electron donors to remove nitrate from contaminated soils. The study was conducted on the Central Plains Experimental Range. CPER is located on shortgrass steppe within the Pawnee National Grasslands in northeastern Colorado. Soil cores were collected to a depth of 160 cm beneath a cattle pen and nitrate content, soil moisture, and denitrifying enzyme activity (DEA) measured. Highest DEA was in the upper 10 cm of the core. While the highest nitrate levels occurred in soils collected from between 40 and 160 cm depth. The addition of vegetable oil to the deeper soils stimulated denitrification at soil moisture concentrations as low as 40% pore filled space. The results suggest that denitrifying biobarriers formed by injecting vegetable oil into the ground might be used to prevent the movement of nitrate into the groundwater.

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Reeder, J.D., G.E. Schuman, J.A. Morgan, D.R. LeCain, and R.H. Hart. USDA-ARS Impact of livestock grazing on the carbon and nitrogen balance of a shortgrass steppe.

Rangeland grazing management strategies are developed to enhance livestock production while sustaining the forage resource. However, grazing strategies also influence soil chemical and physical properties, as well as the distribution and cycling of nutrients. We evaluated the plant:soil C and N balances of a shortgrass steppe under three cattle stocking rates (0, 17, and 37 heifer days ha<sup>-1</sup>) for the past 55 years. Above ground vegetation was sampled (0.18 m<sup>2</sup> frames) at peak standing crop and segregated into warm season grasses, cool season grasses, annual and perennial forbs, litter and standing dead biomass. Root biomass was sampled within each clipped frame to a 30 cm depth with a 9.9 cm diam. core. Soil cores (4.6 cm diam.) were collected to 60 cm depth within each clipped frame and partitioned into six depth increments: A horizon: 0-3.8, 3.8-7.6, 7.6-15; and B horizon: 15-30, 30-45, and 45-60 cm.

Grazing did not affect the amount or distribution of N within the plant: soil (60cm) system. Long-term grazing at the heavy stocking rate, however, resulted in an increase in total soil C, and in total ecosystem C, whereas the light stocking rate did not affect the amount or distribution of C within the plant:soil system. Grazing at the heavy stocking rate resulted in a plant community dominated by warm season grasses (75% of aboveground biomass) and a root/shoot ratio of 13.1, while the plant community under light grazing exhibited a large forb component (45% of aboveground biomass) and a root/shoot ratio of 5.2. The increase in soil C with heavy grazing is in part the result of grazing-induced increases in warm season grasses, which transfer more photosynthate belowground than do forbs or cool season grasses. Heavy animal traffic also enhanced breakdown and decomposition of aboveground litter and incorporation into the soil. The increase in ecosystem C with heavy grazing appears to be related to higher CO<sub>2</sub> exchange rates in those years with warm, dry spring conditions, which favor the growth and photosynthesis of C<sub>4</sub> (warm season) species.

(See companion paper by D.R. LeCain et al., for results of a study comparing CO<sub>2</sub> exchange rates in these same pastures.)

Two Years of Carbon Dioxide Enrichment on the Shortgrass Steppe of Colorado  
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This study assessed how doubling the CO<sub>2</sub> concentration over present levels affects the growth and physiology of shortgrass steppe vegetation in eastern Colorado. In March, 1997, six open-top chambers (OTCs) were installed on native shortgrass steppe in NE Colorado. Three grass species make up about 88% of the above-ground biomass at this experimental site; *Bouteloua gracilis* (C<sub>4</sub>), *Pascopyrum smithii* (C<sub>3</sub>) and *Stipa comata* (C<sub>3</sub>). More than 20 other grass and forb species also occur here. CO<sub>2</sub> was injected into three OTCs to raise the concentration to 720 ppm, approximately twice that in the three ambient chambers. Three non-chambered plots were established to evaluate chamber effects. Phytomass measurements determined on the experimental plots in 1996, one year prior to imposition of CO<sub>2</sub> treatments, indicated similar initial conditions in the three treatment areas (Fig. 1). During 1997 and 1998 significant chamber and CO<sub>2</sub> effects were detected. Averaging over the two years, above-ground production in the ambient chambers was 22% greater than that in unchambered plots, probably due to warmer spring temperatures in the chambers. The air temperature in the chambers averaged 2° C warmer than outside. Production under elevated CO<sub>2</sub> averaged 35% greater than that in ambient OTCs. Significant growth increases occurred for both C<sub>3</sub> and C<sub>4</sub> grasses and forbs in 1998. These CO<sub>2</sub>-induced growth increases were primarily due to improved water status. Soil water content was often higher in elevated CO<sub>2</sub> chambers. Leaf water potentials were generally higher in plants grown at elevated CO<sub>2</sub> compared to ambient chambers. Leaf intercellular CO<sub>2</sub> photosynthesis response curves indicated neither *P. smithii* nor *B. gracilis* leaves were saturated with CO<sub>2</sub> at 360 ppm. Photosynthetic capacity of both species was reduced in plants grown at elevated CO<sub>2</sub>, although this response was much stronger in the C<sub>3</sub> species, *P. smithii*. Results suggest that future CO<sub>2</sub> enrichment will lead to growth enhancements in both C<sub>3</sub> and C<sub>4</sub> grasses of the shortgrass steppe.

FACULTATIVE TORPOR IN FREE RANGING BLACK-TAILED PRAIRIE DOGS  
(CYNOMYS LUDOVICIANUS)

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Although facultative torpor has been observed in laboratory populations of black-tailed prairie dogs (Cynomys ludovicianus), it is widely believed that these animals remain active throughout the winter in the field. We monitored body temperatures ( $T_b$ ) of black-tailed prairie dogs in the field for ~100 days during the winter and spring. All animals entered torpor during this period, and major torpor bouts averaged 133.81 ( $\pm 2.38$ , range = 77.6 to 190.62) h in length with the minimum  $T_b$  dropping to levels of 18.35°C ( $\pm 3.60$ ). Minor torpor bouts averaged 37.55 ( $\pm 20.91$ , range = 9.53 to 84.4) h in length, with minimum  $T_b$  reaching 30.07°C ( $\pm 2.31$ ). There was no distinct relationship between ambient temperature ( $T_a$ ) and entry into torpor. All torpor bouts occurred following a sudden reduction in  $T_a$ , however not all sudden reductions in  $T_a$  induced torpor. Precipitation was not associated with entry into or arousal from torpor. This study demonstrates that facultative torpor is a strategy used by black-tailed prairie dogs in the field.

# **CATTLE GRAZING INTENSITY AND PLANT BIODIVERSITY ON SHORTGRASS STEPPE AFTER 55 YEARS**

**Richard H. Hart**

Shortgrass steppe rangeland near Nunn, Colorado, USA, has been lightly, moderately, or heavily grazed by cattle for 55 years. Exclosures have been protected from grazing for the same length of time. Plant species biodiversity and evenness were greatest in lightly- and moderately-grazed pastures. Both pastures were dominated by the warm-season shortgrass blue grama, but the cool-season midgrasses western wheatgrass and needle-and-thread contributed significantly to biomass production on the lightly-grazed pasture, as they did in the exclosures. Diversity was least in the exclosures, which were strongly dominated by the cactus plains pricklypear. Blue grama and buffalograss, another warm-season shortgrass, were co-dominants under heavy grazing, and diversity was intermediate. Plant community structure and diversity were controlled by selective grazing by cattle, soil disturbance by cattle and rodents, and weather. Shortgrass steppe moderately or heavily grazed by cattle was similar to and probably as sustainable as steppe grazed for millenia by bison and other wild ungulates, as described in early travellers' journals.

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Mosier, Arvin; Morgan, Jack; Parton, William; Milchunas, Dan; Ojima, Dennis. Trace gas exchange in the Colorado shortgrass steppe under elevated CO<sub>2</sub>.

A large open-top-chamber (OTC) study was initiated in 1997 to determine ecosystem responses to doubling atmospheric CO<sub>2</sub> concentration. Little is known of how elevated CO<sub>2</sub> affects soil microbial processes involved in soil respiration, methane oxidation and nitrogen transformations. To study this, chamber measurements of CO<sub>2</sub>, CH<sub>4</sub>, NO<sub>x</sub> and N<sub>2</sub>O fluxes were made weekly from April 1997- March 1998 in areas of grassland that were exposed to ambient or double ambient CO<sub>2</sub> concentrations during March to October, 1997. During the growing season, volumetric soil water content (0-15 cm) was higher under elevated CO<sub>2</sub> while N<sub>2</sub>O emissions were lower (P<0.05). Soil temperature (5-cm), CO<sub>2</sub>, CH<sub>4</sub>, NO<sub>x</sub> and N<sub>2</sub>O fluxes were not statistically different between ambient and double CO<sub>2</sub>. During the winter, only soil water content was appreciably higher (P<0.09) in the elevated CO<sub>2</sub> plots. Even though soil T averaged about 16° C lower during the cold half of the year, CH<sub>4</sub> flux averaged just 17% lower and N<sub>2</sub>O flux was essentially unchanged compared to the warmer half of the year. Because of higher atmospheric concentrations and lower temperature, net NO<sub>x</sub> consumption was observed during the cold season, compared to relatively high net emissions during the growing season. Although higher soil water contents in the surface 15-cm of soil were observed under elevated CO<sub>2</sub>, trace gas fluxes were not greatly affected during the first year of CO<sub>2</sub> enrichment.

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Hoffman, Aaron. A multi-scale assessment of beetle and landscape scaling properties.

The scaling properties of beetles and their relationship to landscape heterogeneity were examined on the short-grass steppe of the Central Plains Experimental Range. The ways in which patterns of beetle, soil and vegetation distributions change with changes in scale of the study were of particular interest. Using coarse-scale maps of primary vegetation and soil texture, four 2-km transects were selected which traverse a gradient of habitat types. Beetles were trapped every 20 m along each transect during 18-23 June and 17-22 August 1998, and later identified to species. A total of 173 beetle species was found in the June and August sampling dates, with 129 beetle species observed in the June sampling and 108 in August. Vegetation surveys were conducted by determining the percent coverage of bare ground, grass, forb, shrub, and cactus, as well as the number of shrubs within a 2 m radius of each trap. Soil texture data were also garnered from GIS coverages of the study area. A moving window analysis will be performed on the beetle, soil, and vegetation data, which will reveal the scales at which different patterns of distribution are seen in the data. Multiple regression at several scales will also be performed in order to determine the scale(s) at which the highest correlations between beetles, vegetation and soil data are seen. This study will provide insights into how the beetle community is coupled to the characteristics of the landscape, as well as the ways in which these relationships may change with associated changes in scale of the study area. It will also provide insight into the general ecology of beetle communities, as well as contribute to our knowledge of basic scaling relationships in ecology. Finally, this study may also provide insights into ways that patterns seen at small scales may be extrapolated to larger, management-scale studies.

Guenther, D.A. and J.K. Detling. Department of Biology, Colorado State University, Ft. Collins, CO, 80523. Cattle use of prairie dog towns on the shortgrass steppe.

The status of the prairie dog (*Cynomys* spp.) as a competitor with other herbivores for forage has long been disputed. Studies on the North American mixed-grass prairie have found that native large herbivores prefer to graze on prairie dog towns. To assess the use of prairie dog towns by cattle on the shortgrass steppe of Colorado, we conducted driving, focal animal, foraging, and vegetation surveys on the Shortgrass Steppe LTER from June to August of 1999.

Twelve pastures containing prairie dog towns were visited three times a week, and the number of cattle grazing or resting on the prairie dog town was noted. Three of these pastures were further intensively surveyed twice a week for a 3 1/2 hour period wherein the habitat and activity of a randomly chosen focal cow or steer was recorded every six minutes. Bite and step counts of other random individuals were recorded for five minute intervals. Vegetation cover and frequency by species and height data were collected once each month in the intensive pastures.

Analysis of the results thus far has shown that cattle randomly used the 15 prairie dog towns observed on driving surveys. The three intensively surveyed pastures yielded similar results; i.e., cattle did not significantly prefer or avoid the prairie dog towns. Vegetation on the prairie dog towns was usually significantly ( $P < 0.05$ ) shorter than that off prairie dog towns. Therefore, even though there was less biomass on the towns, cattle did not avoid grazing on them.

## The Work Of The SGS-LTER Field Crew

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Research that is conducted on the Shortgrass steppe is designed to study the entire ecosystem including below ground and above ground plant biomass, invertebrates, birds, herps, mammals, and the impact of different land uses. A work force of three to twelve people is utilized throughout the field season, from April to November, to establish research plots and collect data. The vegetation studies that are performed by the SGS-LTER field crew focus on the above and below ground plant biomass, plant phenology of several species, the composition of various elements and compounds within various plant species from several different habitat types, the population and community of vegetation, and the effects of grazing and the exclusion of grazing on the plant growth, community, and structure. In the past five years, more studies have focused on the population and community dynamics and inter-relationships between invertebrates, herps, birds, and mammals.

**Landscape-Scale Assessment of Plant Diversity Under Mountain Terrain: Integration of Remotely Sensed Data, GIS, and Spatial Statistics.**

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**Abstract:**

The integration of remotely sensed data, GIS, and spatial statistics provides useful tools for modeling large-scale and small-scale variability to predict distribution, presence, and pattern of native, exotic, and soil characteristics of landscape-scale under mountain terrain. An area about 9252 ha. Was selected as a study site within the eastern region of Rocky Mountain National Park, Colorado, USA. To predict the distribution of exotic species richness, a new model using trend surface analysis and stepwise regression were used. This process is based on the ordinary least square (*OLS*). For large-scale variability, the variables Landsat TM (band 3, band 5), elevation, number of native species, sand, carbon, and silt were highly significant with  $R^2 = 0.6734$  and  $p$ -value less than 0, while for native species richness, only Landsat TM (band 1, band 2, and band 4) were significant with  $R^2 = 0.121$  and  $p$ -value less than 0. Both exotic and native species predictive models were selected for lowest values of *AICC*. To model the spatial continuity of small-scale variability based on cokriging, a gaussian variogram model selected for the lowest values of *AICC*. This model was used to predict the presence of soil variables (carbon, sand, and silt). In addition, cross-correlation statistics suggested that at large-scale, native and exotic plant species were spatially independent throughout the study site. That is, the spatial relationship of native and exotic species richness with their own kind were not statistically significant. However, these results may be different for individual plant species. Finally, different thematic maps were produced for native and exotic species richness, weed probability, and soil characteristics maps.

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Woodard, J. D. Burrowing owl (*Speotyto cunicularia*) nesting patterns on the Pawnee National Grassland.

Burrowing owls nest in a variety of habitats; however, this apparent plasticity in nesting requirements has not prevented the burrowing owl from experiencing regional population declines. Despite extensive research devoted to burrowing owl nest-site selection processes, questions remain. At what scale does nest-site selection occur? To what extent does spatial and temporal variation in habitat parameters affect nesting patterns and reproductive performance? These questions are being examined in a study of burrowing owl nesting patterns on the Pawnee National Grassland, Weld County, Colorado. The objectives of the study are to (1) identify the scale(s) at which nest-site selection occurs, and (2) determine the extent to which variation in measured burrow, colony, and landscape characteristics affect nesting patterns and fitness. Habitat and demographic data were collected at 103 nest sites located on 26 active black-tailed prairie dog (*Cynomys ludovicianus*) colonies. The density of satellite burrows around a nest site was recorded at three intervals: 0-10 meters, 10-20 meters, and 20-30 meters. Nest burrows and colony perimeters were mapped with a hand-held GPS unit. Satellite burrow density, colony area, and nearest nesting neighbor distance calculations will be related to minimum productivity and nesting success estimates. Landscape analyses will be conducted using geographic information systems (GIS), field GPS data, and existing LTER drainage, road, and vegetation data. No analyses have been conducted to date. A second field season is anticipated to supplement the breeding data recorded during 1999. One additional consideration for the 2000 field season is acquiring disturbance information. A quick review of the 1999 dataset suggests nesting densities and productivity may be influenced by prairie dog control programs. The study results will be used to further our understanding of nesting patterns, specifically the role of the landscape in nest-site selection processes, and will provide land managers and conservationists with baseline information concerning burrowing owl reproductive success on the Pawnee National Grassland.

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## **DYNAMICS OF EXOTIC SPECIES AND THEIR ESTABLISHMENT IN THE PAWNEE NATIONAL GRASSLAND**

◇ Dani-Ella Betz and Dr. W. K. Lauenroth ◇

### POSTER ABSTRACT

During the summer of 1998, our project focused on the distribution of exotic species or weeds, in the Pawnee National Grassland. Forty-five paired roadside and open steppe sites were surveyed to estimate the species richness, canopy cover and number of individuals in 3 x 1 meter plots. The results demonstrated that roadsides contained significantly fewer native species than the open steppe. Very few exotic species were found in the open steppe (average per 3 x 1 m plot = .42 species) while the roadsides contained significantly more (average = 4.6 species). It appeared that the roadside exotic plant species are not encroaching on the native open steppe. In addition, this study showed a significant difference in native species richness when grazed and ungrazed roadsides were compared. Canopy cover of the native grasses, blue grama (*Bouteloua gracilis*) and buffalo grass (*Buchloe dactyloides*), was higher on the grazed roadsides than the ungrazed roadsides. To understand the dynamics of establishment in the open steppe we also examined the seedbank along a transect from roadsides to 25 meters into the open steppe. We found that a greater number of seeds of exotic species were found in the roadsides (7.0=average number of exotic seeds per sample) versus the open steppe (0.8=average), and fewer seeds of native species were found in the roadsides than the open steppe.

To further investigate why roadside exotic plant species have not encroached onto the native open steppe, in 1999 we planted exotic species into the open steppe. Two species were chosen, one exotic grass, downy brome (*Bromus tectorum*), and one exotic forb, Dalmation toadflax (*Linaria dalmatica*). To examine the important factors in establishment a matrix of 5 treatments were applied: 1) water additions, 2) nitrogen applications, 3) disturbance of soil, 4) light cattle grazing, and 5) water plus nitrogen additions. Dalmation toadflax did not establish in the research plots although downy brome was successful in germinating and establishing. The nitrogen and nitrogen plus water treatments were the most successful in promoting the growth of downy brome as it effectively competed with blue grama in the open steppe.

These preliminary results suggest that during wet years and over time if nitrogen deposition increases due to human sources, a few seeds of exotic species may establish, increasing the number of exotic seeds in the seedbank in the open steppe. If seeds of exotic species eventually become prevalent in the seedbank of the open steppe, then results of this study suggest that an aggressive exotic species invasion may occur in the Pawnee National Grassland.

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Dreyfuss, Adam: A community structure study of Limber pine stands and understory on the short grass steppe and a GIS analysis of eastern Colorado xeric tree stands' change over time.

The understory of the 6 sites containing limber pine stands were examined using a Daubenmire plot. 200 randomly chosen points within each site were sampled for species type, vegetative cover percentage and basal cover percentage. The trees in the plots were measured for diameter at breast height, height, and qualitative measures of health and fecundity. Further for both the tree and understory measurements slope and aspect were recorded.

Increment bores will be taken on the limber pines in the site to determine the age structure of the stands. Old stumps and other dead material that can be found will be included to extend the period analyzed.

Archival and current ariel photography which include areas of xeric pines in eastern Colorado will be digitalized and analyzed using GIS. The trends found both through the GIS analysis and tree ring counts may be valuable in determining both the climatic history of the region and more specifically how el nino and la nina events affect the short grass steppe and the xeric pines which grow there.

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Farrar, J.P. and J. K. Detling. **Black-tailed Prairie Dog Mounds: Do they contribute to plant species diversity and nitrogen cycling?**

Prairie dog mound building is a natural disturbance of plant communities of the shortgrass steppe. Other investigators have shown that mounds of other burrowing mammals contribute to the creation or maintenance of plant species diversity. Therefore, we hypothesize that one or more sub-dominant, and possibly rare, plant species are found in greater abundance on black-tailed prairie dog (*Cynomys ludovicianus*) mounds than in off-mound areas or off prairie dog town areas. In addition, we hypothesize that soil mixing results in enhanced N-mineralization which increases N-content of plants growing on mounds. During the summer of 1999 we took cover measurements and collected plant samples from plots on 3 active and 3 inactive prairie dog towns on the Pawnee National Grasslands in northeastern Colorado. We are currently analyzing the samples for biomass and nitrogen content, and will compare these results with those collected from off-mound and off-town sites. Preliminary results suggest *Solanum triflorum*, *Sphaeralcea coccinea*, and *Verbena bracteata* exhibit greater percent cover on prairie dog mounds.

# Are Bird and Rodent Responses to Livestock Grazing Related to Plant Community Productivity and Evolutionary History of Grazing?

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The effects of grazing by domestic livestock on bird and rodent communities and species are often thought to be highly mediated through the impact of the herbivores on plant community physiognomy, productivity, and species composition, although other factors may also be important. Because of the large number of studies, grazing effects on plant communities across a broad geographic range of ecosystems has been shown to increase with increasing aboveground primary productivity and shorter evolutionary history of grazing. Our objectives in this analysis are to broadly assess whether bird and rodent responses to grazing of North American rangelands are related to factors important in the relative magnitude of vegetation responses, and whether grazing is generally detrimental to less abundant or declining bird species and beneficial to abundant or increasing species.

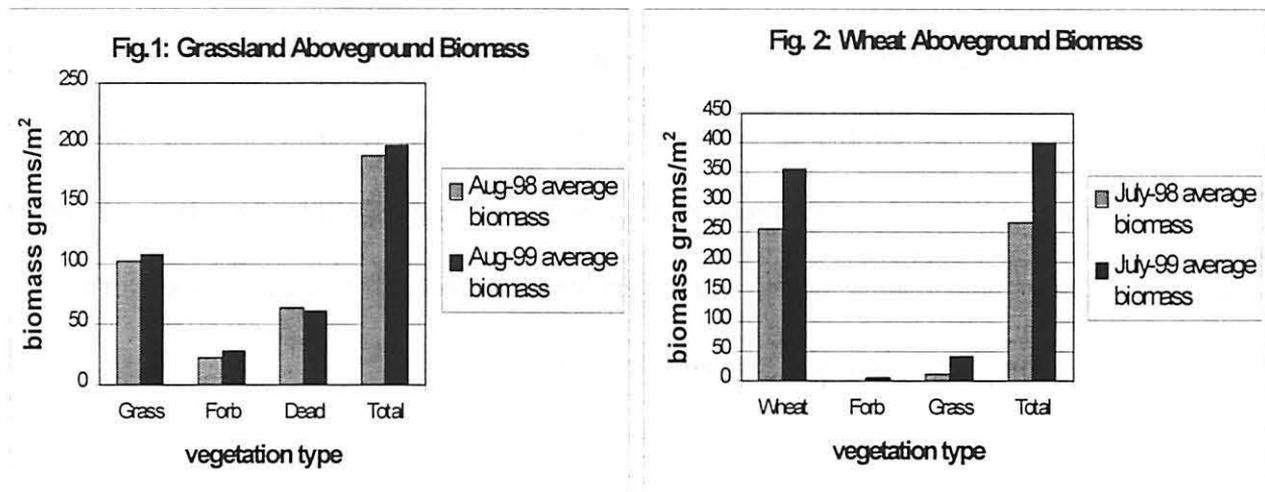
Bird communities in systems with short- versus long- evolutionary histories of grazing displayed responses to grazing similar to that of vegetation, but rodents did not. Bird community dissimilarities with grazing were greater, abundances negatively versus positively affected, and richnesses decreased versus little affected in systems with short compared to long evolutionary histories of grazing. Rodent responses were sometime opposite or highly variable, but there were often species sampled uniquely in more lightly grazed treatments. Bird and rodent responses to grazing along gradients of aboveground primary production were also often different. Bird response to grazing displayed an increase in community dissimilarity with increasing primary productivity across grasslands of the Great Plains, but rodents did not. Bird abundance responses to grazing were usually highly positive in productive mixedgrass prairie, less positive in low productivity shortgrass steppe, and intermediate in mixedgrass prairies. Rodent abundance was usually negatively affected in all Great Plains plant communities, but became increasingly so with increasing plant community productivity. Neither bird nor rodent diversity or richness displayed a clear response relationship with increasing primary productivity, but across all studies the responses to grazing were most often negative. Birds appear to track grazing influences on vegetation more closely than rodents, but neither may be considered more sensitive indicators of grazing impacts than plants except under certain conditions.

With a few exceptions, previous classifications of birds as increasers or decreaseers with grazing were supported. Although some bird species were generally either positively or negatively affected by grazing, no rodent genus consistently showed increases with grazing across North American sites, although grasshopper mice and white-footed mice responses were often positive. Some bird and rodent species are considered to have specific, or optimum habitat requirements in terms of vegetation density or height, but there were insufficient data over grazing intensity gradients to assess whether a particular bird species or rodent genus preferred a different grazing management in communities of different productivity. Only a very weak suggestion was found that would suggest less abundant or declining bird species are generally more negatively impacted by grazing than are abundant and increasing species, and there was no relationship for primary grassland species.

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Smith, D. P. and Lauenroth, W.K.. Primary production of summer-fallow winter wheat and native grasslands in Northern Colorado.

The influence of landuse has greatly affected the structure and function of grassland ecosystems. It is estimated that approximately half of native perennial grasslands in the central grassland region of the United States have been converted to annual croplands (Lauenroth et al. submitted). This study focused on the shortgrass steppe ecosystem and its conversion to summer-fallow winter wheat. The conversion of native grasslands to croplands has altered primary production dynamics and influenced biomass allocation. Additionally, the conversion of native grasslands to croplands affects the dynamics of soil water. There were two primary objectives of this study. The first was to compare above and belowground net primary production of summer-fallow winter, adjoining fallow strips and native shortgrass steppe grasslands. Secondly, to examine the soil water dynamics of summer-fallow winter, adjoining fallow strips and native shortgrass steppe grasslands. Samples were collected in three wheat fields and three adjacent grassland sites. All sites were located in north central Weld County, Colorado. Biomass production was sampled in three treatments: wheat, wheat fallow and grassland. In each treatment, aboveground and belowground biomass was collected using the harvest method. Aboveground biomass was collected by clipping circular quadrates and belowground biomass was collected using soil cores to collect roots. Gravimetric soil moisture data and simulation modeling were used to examine the soil water dynamics in each treatment. Results of this study are preliminary as data is still being processed. Collected data has not been statistically analyzed however raw data is presented here in graphical format. Average aboveground biomass in native shortgrass steppe sites and summer-fallow winter wheat is depicted in Figure 1 and Figure 2 respectively.



**EFFECTS OF THE PONNEQUIN WIND ENERGY STATION,  
NORTHERN WELD COUNTY, COLORADO,  
ON SOME BIRDS AND MAMMALS**

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Birds and mammals have been censused on four study sites at the Ponnequin Wind Energy Station of the Public Service Company of Colorado. Since 1 June 1999, 29 towers have been in operation. Two sites have windmills and two were reference areas with no windmills. Three types of censuses were used: a strip count under the windmills, point counts for raptors, and plot counts perpendicular to the power tower lines. One year of counts was made before construction and 6-12 months after construction. All four areas were counted weekly in the summer, twice monthly in the spring and fall, and monthly in the winter.

Avian surveys revealed no endangered, threatened, or species of concern on the sites and few raptor nests within 5 km of the project area. Horned Larks and McCown's Longspurs (both nesters) accounted for 84.8% of all songbirds observed on the project and reference sites. The remainder were mainly Lark Buntings and Western Meadowlarks (also nesters), although over 20 species have been observed in migration. Three raptor species (Golden Eagle, Swainson's Hawk and Ferruginous Hawk) accounted for 74.9% of the 76 hawk sightings on all sites. Territorial displays and hunting behaviors related to windmill operational heights will be described. To date, 5 bird and 4 bat fatalities related to the wind towers have been noted. Pronghorns and Horned Larks have been attracted by grass seedings under the towers.