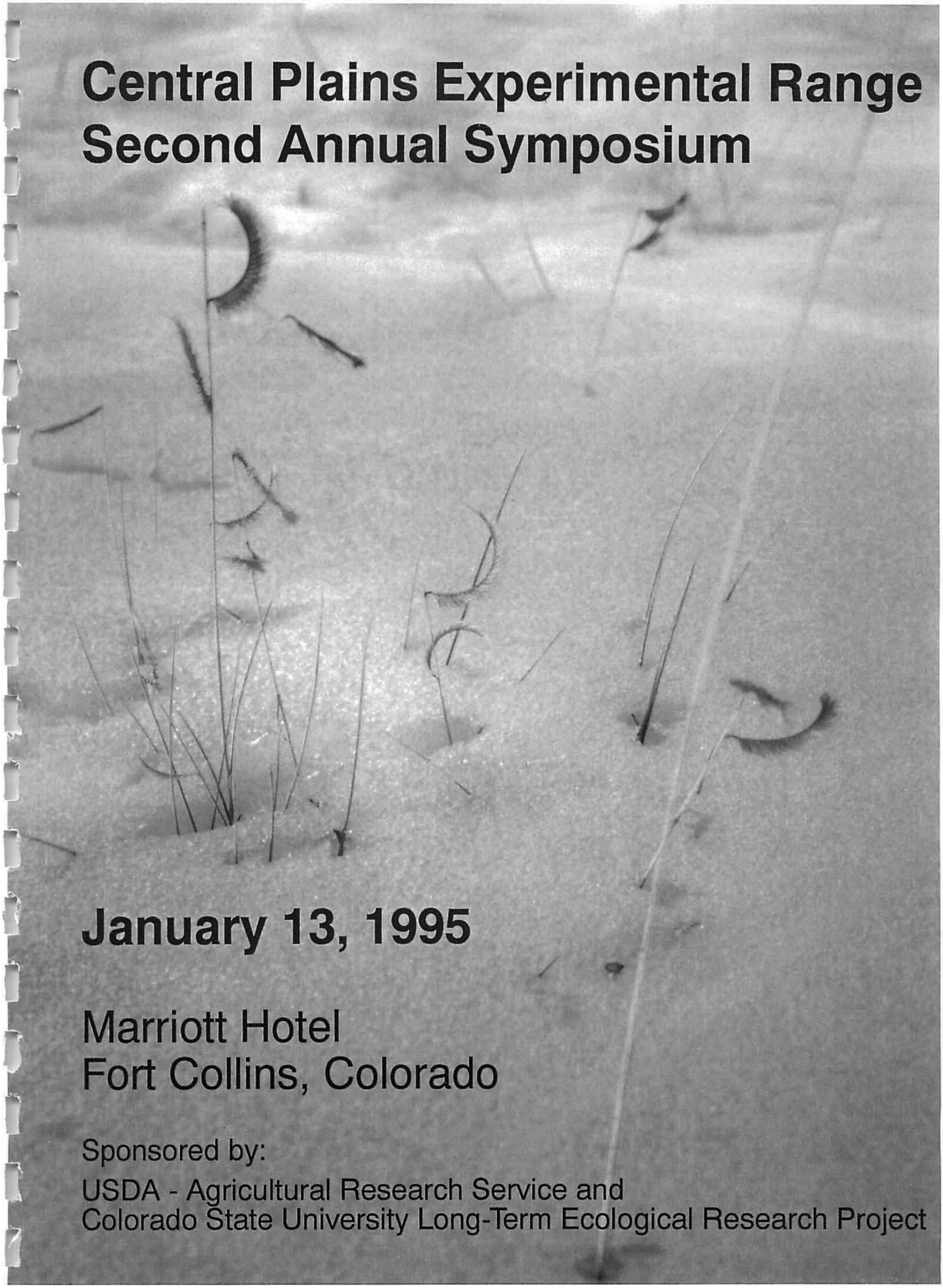

Central Plains Experimental Range
Second Annual Symposium

January 13, 1995

Marriott Hotel
Fort Collins, Colorado

Sponsored by:

USDA - Agricultural Research Service and
Colorado State University Long-Term Ecological Research Project

CPER Symposium

Agenda

January 13, 1995

8:00	Arrival and Poster Mounting (Coffee and Sweet Rolls)	
8:30	Welcome and Introduction	
8:45	Keynote Address: "Perception is Reality? Science and Attitudes in Range Policy"	
	Bill Riebsame, the University of Colorado	
9:30	Presentation	
	"Soil-Atmosphere Exchange of CH_4 and N_2O at the CPER"	
	Presenter:	A. R. Mosier
	Contributors:	D. W. Valentine, W. J. Parton, D. S. Schimel D. S. Ojima, M. C. Skoles and R. E. Martin
10:15	Break and Posters	
12:00	Lunch "A visit from Teddy Roosevelt"	
1:15	Presentations	
	"Stable carbon and oxygen isotope studies at the CPER"	
	Presenter:	Gene Kelly
1:45	"Grazing studies at the CPER"	
	Presenters:	Dick Hart and Daniel Milchunas
2:30	Break and posters	
4:00	Adjourn	

CPER Symposium Participants

Martin Aguiar	CSU - Graduate Degree Program in Ecology
Christine Althouse	CSU - Fishery & Wildlife Biology Department
Richard Alward	CSU - Biology Department
Mary Ashby	USDA-ARS Rangeland Resources Research Central Plains Experimental Range
Menweylet Atsedu	CSU - Natural Resource Ecology Laboratory
Jeb Barrett	CSU - Graduate Degree Program in Ecology
Eddie Bebout	University of Northern Colorado Biology Department
Dave Bigelow	USDA UV-B Monitoring Program Natural Resource Ecology Laboratory
Indy Burke	CSU - Forest Sciences Department and Natural Resource Ecology Laboratory
Tim Carney	USDA-NRCS-Weld County Greeley, CO
Andrea Cibils	CSU - Rangeland Ecosystem Science
Debra Coffin	CSU - Rangeland Ecosystem Science Department and Natural Resource Ecology Laboratory
Martha Coleman	CSU - Forest Sciences Department
Bill Davis	USDA UV-B Monitoring Program Natural Resource Ecology Laboratory
Mike Dodd	CSU - Rangeland Ecosystem Science Department
Bill Durham	USDA UV-B Monitoring Program Natural Resource Ecology Laboratory
Ted Elliott	CSU - Natural Resource Ecology Laboratory
Howie Epstein	CSU - Graduate Degree Program in Ecology

Jim Fitzgerald	**UNC - Biology Department Greeley, CO**
Harold Fraleigh	**CSU - Graduate Degree Program in Ecology**
Diana Freckman	**CSU - Natural Resource Ecology Laboratory**
James Gibson	**CSU - Natural Resource Ecology Laboratory**
Dick Hart	**High Plains Grasslands Research Station Cheyenne, WY**
Jack Hautaluoma	**CSU - Psychology Department**
Charlie Hawkins	**CSU - Rangeland Ecosystem Science Department**
Judy Hendryx	**CSU - Rangeland Ecosystem Science Department**
Shiou Pin Huang	**CSU - Natural Resource Ecology Laboratory**
Bill Hunt	**CSU - Rangeland Ecosystem Science Department Natural Resource Ecology Laboratory**
Carol Jacobs-Carrē	**CSU - Rangeland Ecosystem Science Department**
Anita Kear	**USDA-ARS, Soil-Pl Nutrient Research Natural Resource Ecology Laboratory**
Robin Kelly	**CSU - Graduate Degree Program in Ecology**
Gene Kelly	**CSU - Soil and Crop Science Department**
Tom Kirchner	**CSU - Natural Resource Ecology Laboratory**
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Mark Lindquist	**CSU - Rangeland Ecosystem Science Department Central Plains Experimental Range**
Jeff Losche	**Pawnee National Grassland and Arapaho and Roosevelt National Forests**
Pam Lyman	**Crow Valley Livestock, Crops**
Robin Martin	**CSU - Natural Resource Ecology Laboratory**
Gustavo Martinez	**CSU - Rangeland Ecosystem Science Department**
Lowel McEwen	**CSU - Fishery & Wildlife Biology Department**

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Rebecca Roof	USDA-ARS Rangeland Resources Research Central Plains Experimental Range
Tom Rossi	CSU - Graduate Degree Program in Ecology

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Susan Smith	CSU - Rangeland Ecosystem Science Department
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Dave Valentine	CSU - Natural Resource Ecology Laboratory
Mary Ann Vinton	CSU - Forest Sciences Department
Ron Weeks	CSU - Entomology/Ecology Departments
Jeff Welker	CSU - Natural Resource Ecology Laboratory
Jim Welsh	USDA-ARS National Resource Research Center
Caroline Yonker	CSU - Agronomy Department
Yanqing Zhang	CSU - Natural Resource Ecology Laboratory

Presenters of Posters

Aguiar, Martin	**Experimental addition of water and nitrogen and the competition between dominant grasses in the shortgrass steppe.**
Alward, Richard	**Long-term responses of shortgrass steppe vegetation to increased temperatures.**
Ashby, Mary M., Richard H. Hart	**Plant community responses to fifty years of grazing on shortgrass prairie.**
Ashby, Mary and Jeff Thomas	**A historical perspective of the CPER.**
Astedu, Menwyelet	**Effects of grazing history and defoliation on plant morphology, biomass, and N dynamics in the shortgrass steppe.**
Burke, Ingrid C.	**Effects of grazing and exclosure on soil organic matter pools and nitrogen availability in a shortgrass steppe.**
Coffin, Debra P.	**Regional analysis of the recruitment of the perennial grass, *Bouteloua gracilis*: effects of climate change.**
Elliott, Edward T.	**Response of soil properties under C3 and C4 perennial grasses to elevated CO_2 and climate change.**
Epstein, H. E.	**Productivity of C_3 and C_4 functional types in the great plains of the U.S.**
Fitzgerald, Jim	**Ecology of the swift fox, Vulpes velox, in northern Weld County.**
Gibson, James H.	**USDA UV-B Radiation Monitoring Program.**
Huang, Shiou Pin	**Nematode biodiversity and grazing effects on nematode populations in the shortgrass steppe of CPER.**
Kelly, Robin H.	**Soil organic matter loss in the shortgrass steppe: role of plant removal.**
Lauenroth, Bill	**Analysis of the distribution of C_3 and C_4 grasses between the Northern Mixed Prairie and the Shortgrass Steppe.**

Lindquist, Mark D., Paul Stapp	Monitoring studies of small mammal populations on the Shortgrass Steppe Long-Term Ecological Research site.
Lyman, Pamela	Hydrologic impact of animal, municipal and industrial waste on rangelands.
Martin, R. E.	Water and temperature controls on NO and N_2O soil fluxes from denitrification shortgrass steppe.
Martinez-Turanzas, Gustavo A.	Effects of disturbance size and soil texture on microtopography in a shortgrass community.
McEwen, Lowell or Brett E. Petersen	Effects of grasshopper insecticides on wildlife in a rangeland IPM System.
McIntyre, Nancy E.	Effects of a methamidophos application of *Pasimachus elongatus* LeConte (Coleoptera: Carabidae): An update after six years.
Milchunas, Daniel G.	Consistency in plant community response to grazing and protection.
Minnick, Tamera J.	Predicting germination and establishment of *Bouteloua gracilis* and *bouteloua eriopoda* across an environmental gradient using soil-water model.
Morgan, Jack	Photosynthetic and growth responses of NAD-ME and NADP-ME type C_4 grasses grown at elevated CO_2.
Mosier, Arvin R.	Methane and nitrous oxide fluxes in grasslands in Alaska, Colorado and Puerto Rico.
Mueller, Dennis	Effects of livestock grazing reduction on infiltration and runoff from native shortgrass rangelands.
Parton, W. J.	General model of N_2 and N_2O fluxes from nitrification and denitrification.
Paruelo, José	Climatic controls of the distribution of plant functional types in grasslands and shrublands of North America.
Paruelo, José	Regional Climatic Similorities in the temperate zones of North and South America.
Reeder, Jean D.	Utilization of municipal, industrial and animal wastes on semiarid rangelands.

Robles, Marcos	**The influence of the Conservation Reserve Program in the recovery of soil organic matter in previously cultivated soils.**
Smith, Susan	**Change in atmospheric CO_2 levels and the relationship between decomposition and chemical quality of shoots of Blue Grama and Western Wheatgrass.**
Vinton, Mary Ann	**Plant effects on soil nutrient dynamics along a precipitation gradient in Great Plains grasslands.**
Weeks, Ronald D. Jr.	**Spider diversity and landscape ecology on shortgrass prairie.**
Welker, J. M., C. Yonker, E. F. Kelly	**A conceptual framework for the CPER-LTER that links the biological, atmospheric and earth sciences.**

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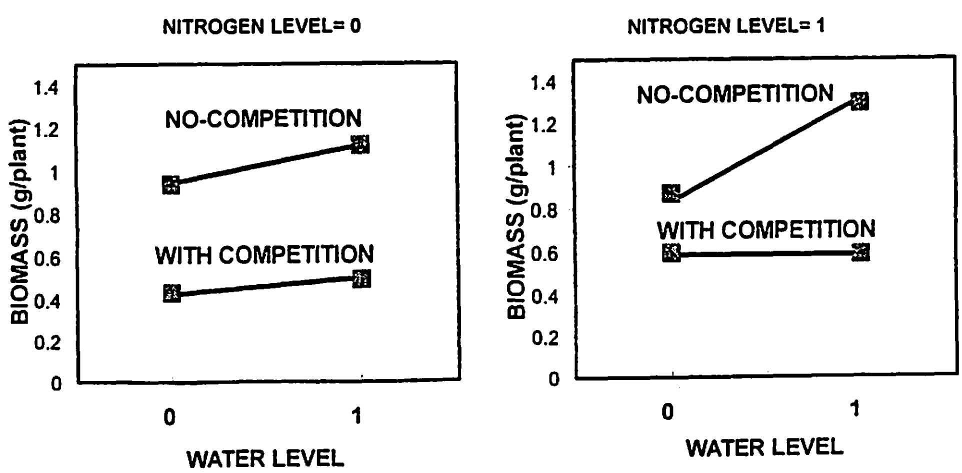
Aguiar, Martín R., William K. Lauenroth and Debra P. Coffin. Experimental addition of water and nitrogen and the competition between dominant grasses in the shortgrass steppe.

Bouteloua gracilis and *Buchloë* dactyloides are dominant and subdominant C_4 species, respectively, throughout a region which includes sites with large differences in water and nitrogen availability. We conducted a field experiment to evaluate the effects of water and nitrogen availabilities on intra- and interspecific competition. Our hypotheses were that both intra- and interspecific competition should be equal and intense for both species. We also proposed that the addition of resources should not change the intensity or the importance of competition. Our garden experiment included both species planted in a honeycomb design. Water additions totalized 163 mm and nitrogen addition was 11 g/m^2. Our competition treatment only manipulated belowground competition.

B. gracilis accumulated more biomass than *B. dactyloides* during the first growing season. While the addition of water increased 23% the biomass, N only increased it 12%. Competition reduced 98% the plant biomass. Only plants that grew without competition did increased the biomass with the addition of resources. The addition of both resources resulted in largest biomass. The intensity and the importance of both intra- and interspecific competition were not affected by the addition of resources.

Our results indicate that the similarities in morphology and ecophysiology between the species is also related with competition abilities when plants grow with different resource availabilities. Our results also did not explain the relative dominance of both species.

WATER x NITROGEN x COMPETITION (p=0.05)



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Alward, Richard D.[1,2], Daniel G. Milchunas[3,4] and James K. Detling[1,2,4]. LONG-TERM RESPONSES OF SHORTGRASS STEPPE VEGETATION TO INCREASED TEMPERATURES. [1]Graduate Degree Program in Ecology, [2]Department of Biology, [3]Department of Rangeland Ecosystem Science and [4]Natural Resource Ecology Lab. Colorado State University, Fort Collins CO 80523

We used climate records from the Central Plains Experimental Range to identify a general warming trend in average annual temperatures over a period from 1971 to 1992. This 21-year trend was largely the result of a significant trend in increased mean annual T_{min} (Fig. 1). We constructed linear correlational models to assess relationships of annual and seasonal temperature trends with plant densities within a grazing exclosure. Permanently marked vegetation quadrats have been monitored for much of this same 21-year period. Several plant species varied in density with temperature trends. In particular, stem densities of the grass *Sitanion hystrix* and the forb *Kochia scoparia* were significantly correlated with increases in annual and spring T_{min}, respectively. Also, species richness, diversity and total basal cover were positively correlated with T_{min} (Fig. 2). However, the dominant grass, *Bouteloua gracilis*, and cool- and warm-season plant functional groups were largely insensitive to temperature trends. This investigation has identified sensitive species that may be used as early indicators of community and ecosystem change in response to climate trends. This investigation also supports predictions that asymmetric changes in diurnal temperatures may be an important component of climate change. We are currently conducting manipulative field experiments to evaluate the causational relationships between increasing minimum temperatures and vegetation in the shortgrass steppe.

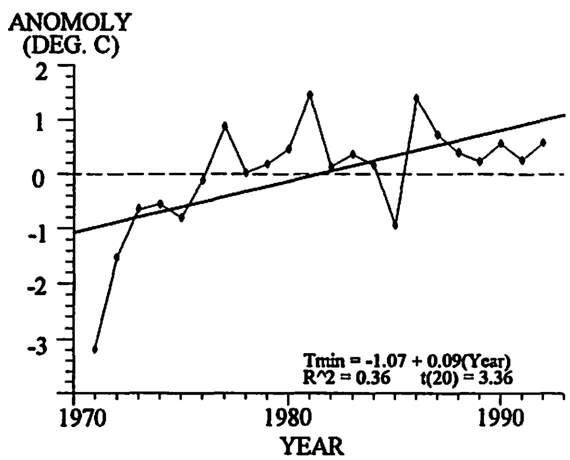

Figure 1. Annual differences (°C) from 21-year means of the annual average minimum temperatures at the CPER. The solid line indicates the significant ($p<0.05$) linear trend given by the regression equation.

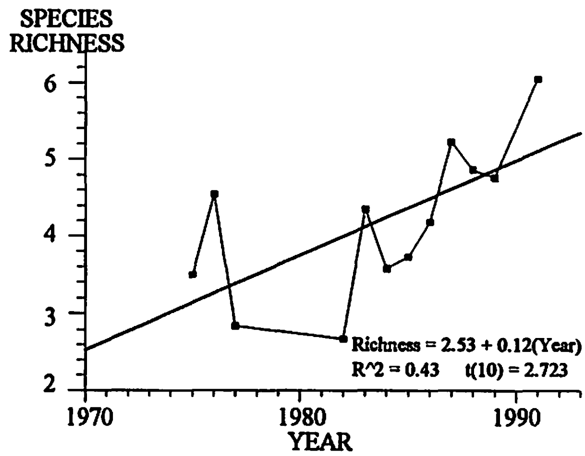

Figure 2. Species richness in ungrazed plots at the CPER since 1975. The solid line indicates the significant ($p<0.05$) linear trend given by the regression equation.

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Mary M. Ashby, Richard H. Hart and James R. Forwood (deceased). Plant Community Responses to Fifty Years of Grazing on Shortgrass Prairie.

Periodic vegetation measurements have been collected from pastures that have been grazed with heavy, moderate and light stocking rates since 1940. The study was conducted on shortgrass prairie at the Central Plains Experimental Range (CPER) northeast of Nunn, Colorado. Dominant warm-season grasses are blue grama and buffalograss and important cool-season grasses include western wheatgrass, needleandthread and bottlebrush squirreltail. Grazing treatments that removed approximately 60, 40 and 20 percent by weight of the current year's growth of dominant forage grasses by the end of the grazing season were respectively designated as heavy, moderate and light grazing until 1965. From 1965 on, the objective for heavy, moderate and light stocking rates was to leave 200, 300 and 450 pounds per acre, respectively, of ungrazed herbage at the end of the grazing season. Only one replication out of four remains in the study. Sampling techniques have not been consistent over the years. Data collected prior to 1991 included 36 years of partial biomass production, only 4 years with total biomass production and 18 years of cover data. In 1991, 1992, 1993 and 1994 total biomass production data was collected and in 1992 1993 and 1994 pastures were sampled for basal cover and frequency of occurrence by species. Fifty-four years of grazing at different stocking rates has had little effect on biomass production of warm-season grasses. Cool-season grass and shrub production decreases with increased stocking rates. Moderate grazing maintains forage production and animal gains. Light grazing provides more species variety but does not utilize the range to its full potential.

Figure 3

Blue Grama and Buffalograss Production

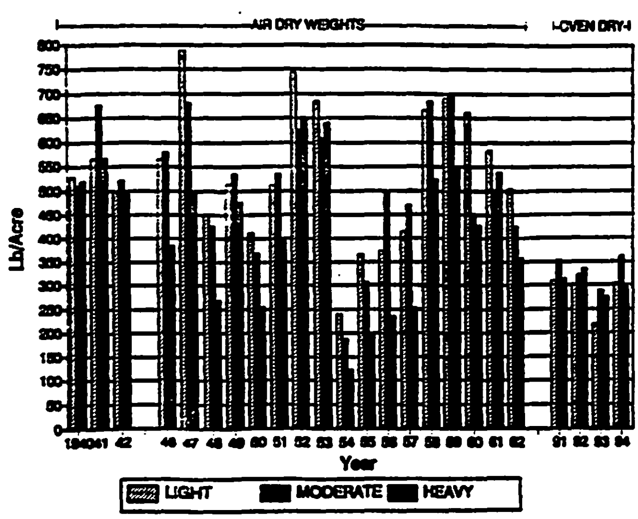
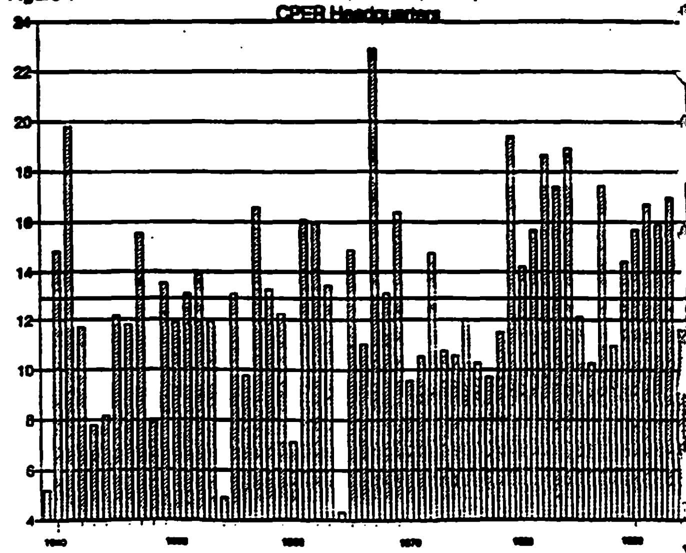


Figure 1

Annual Precipitation (inches)
CPER Headquarters



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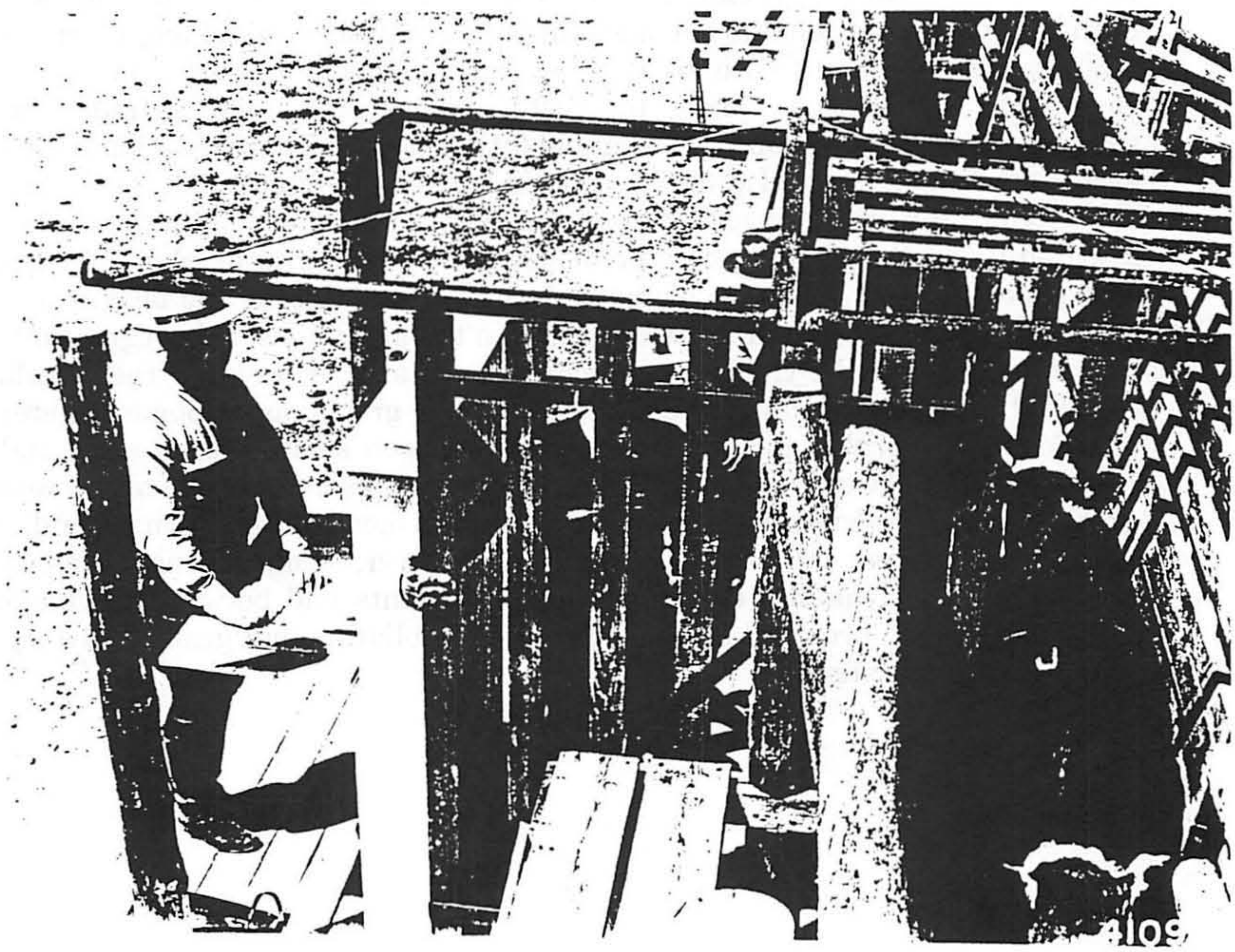
Ashby, Mary M., and Jeffrey B. Thomas. (Non-technical poster) - A Historical Perspective of the CPER.

We were asked to put together a poster displaying some of the history of the CPER. The poster will have old photographs of past researchers, research projects, field days, weather events, etc. Text will include general information, historical dates, research efforts and accomplishments and future studies.



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Menwyelet Atsedu, James K. Detling, and Harold Goetz. Effects of grazing history and defoliation on plant morphology, biomass, and N dynamics in the shortgrass steppe.

This study investigates how the morphology, biomass, and aboveground nitrogen dynamics of *Pascopyrum smithii* (western wheatgrass) and *Bouteloua gracilis* (blue grama) plants are affected by defoliation and grazing history at CPER. A field experiment was carried out in four grazing treatments (long-and short-term grazing and long- and short-term protection) during the 1992 and 1993 growing seasons. We conducted a parallel greenhouse study to examine whether morphological and chemical differentiation due to long-term grazing has occurred. Long-term protection has resulted in plants with taller tillers and longer leaf blades in both species. Defoliation enhanced tillering in western wheatgrass plants under moderate defoliation intensity (clipped at 6 cm height) in long-term grazed plants, and under severe defoliation (clipped at 3 cm height) in long-term protected plants. Tillering was enhanced in the greenhouse by defoliation only in protected populations. Defoliation also reduced tiller density of greenhouse-grown blue grama plants in long-term grazed populations. Although biomass of western wheatgrass and blue grama plants was reduced by defoliation in the field and in the greenhouse, aboveground tissue N concentration and N yield were increased. A similar inverse relationship was observed between biomass and N yield in the greenhouse. Some differences in chemical and morphological characteristics between short-term grazing and short-term protection (two years in both cases) also were observed. Some of our results are consistent with previous findings regarding plant morphology, biomass and tissue N dynamics response following defoliation. However, comparisons of morphology, biomass and N dynamics across grazing treatments and between tiller and plant organization has provided a broader view of defoliation and grazing history effects in the shortgrass steppe.

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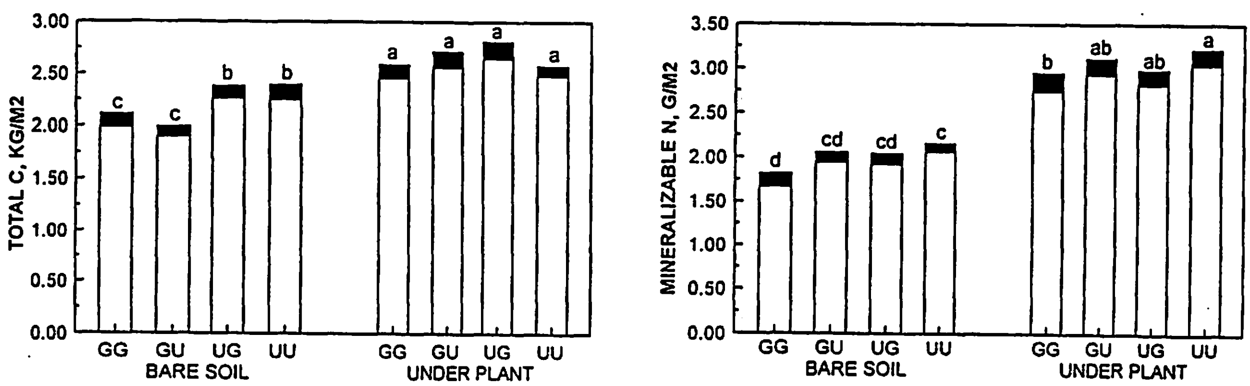
Burke, I. C., P. B. Hook, and W. K. Lauenroth. Effects of grazing and exclosure on soil organic matter pools and nitrogen availability in a shortgrass steppe.

The shortgrass steppe has been grazed by large herbivores throughout recent evolutionary histroy. Studies that address the influence of grazing by cattle have traditionally used exclosures for the purpose of comparison, although exclosure may represent a more unusual condition than cattle grazing. We are conducting a study at the Central Plains Experimental Range (CPER) to evalute the transient and long-term effects of grazing and exclosure on ecosystem structure and function. We have moved 50-year-old exclosures to create new grazing and exclosure treatments in historically grazed and protected areas. Two years after shifting exclosure boundaries, we estimated C and N pools, particulate organic matter, microbial biomass, and mineralizable C and N in soils. We stratified our sampling by under-plant locations and bare soil areas between plants, since we have previously demonstrated significant variation at this scale. Long-term grazed treatments had significantly less total C, N, particulate organic matter, microbial biomass, mineralizable C, and mineralizable N than long-term exclosed treatments, but all variables were significant only in bare soil areas. Two years of new grazing or exclosure treatments were sufficient to alter only the most active pools, as evident in mineralizable C and N. Although grazing and exclosure treatments effects were significant, the magnitude of these differences was small compared with the magnitude of variability conferred by plant - between plant locations. We conclude that grazing and exclosure alter soil organic matter and nutrient availability, these alterations are less than the natural variability of the system conferred by plant presence and absence.



Soil C and mineralizable N in soils from short- and long-term grazing treatments in shortgrass steppe. Treatments are: GG long-term grazed, currently grazed; GU long-term grazed, currently (2 years) ungrazed; UG long-term ungrazed, currently grazed; and UU long-term ungrazed, currently ungrazed. Values are averaged across 6 blocks.

SUMMARY FORM: 1995 CPER SYMPOSIUM

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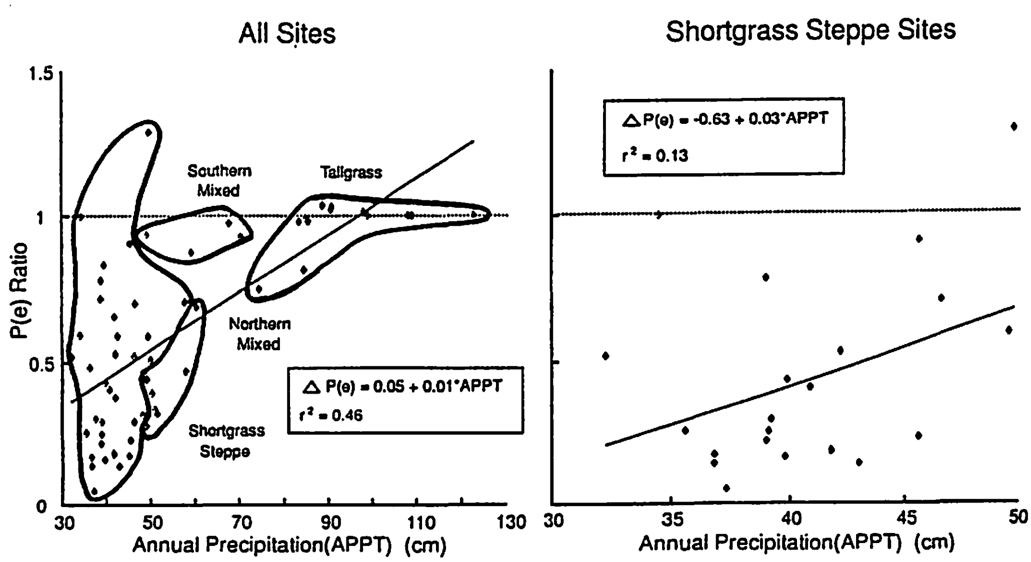
Coffin, Debra P., and William K. Lauenroth. Regional Analysis of the recruitment of the perennial grass, *Bouteloua gracilis*: effects of climate change.

We evaluated the recruitment potential by seedlings of the perennial C_4 grass, *Bouteloua gracilis* (blue grama) for the CPER and the central grassland region of the U.S. under current climatic conditions and for changes in climate. *B. gracilis* is common in all four grassland types of the central grassland region (shortgrass steppe, northern and southern mixedgrass prairies, tallgrass prairie). In addition, *B. gracilis* dominates shortgrass steppe plant communities and is important in the northern mixedgrass prairie. Seedling establishment by *B. gracilis* is important both for recovery after disturbances since tillering rates are slow, and in determining the geographic distribution of abundance of this species. We used a multi-layer daily time step soil water model (SOILWAT) to evaluate the probability of recruitment of *B. gracilis* seedlings for a range of soil textures and a range of current and expected changes in climatic conditions representative of the region. Simulations were conducted using daily precipitation and temperature data for 66 weather stations. Under current climate, probability of recruitment increased with increasing temperature and precipitation, and was positively related to silt content of the soil. Probabilities were lowest in the coolest and driest areas, the northern mixedgrass prairie and the shortgrass steppe, where *B. gracilis* is the most important. Under a climate change scenario (see figure), shortgrass steppe and northern mixedgrass prairie sites had the largest proportional decreases in probability of recruitment, as indicated by the ratio of probability under current climate divided by the probability under climate change [P(e)]. These results indicate that the community types where *B. gracilis* is currently the most important, including the CPER, are expected to be the areas most sensitive to changes in climate.



1995 CPER SYMPOSIUM

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Elliott, E.T., H.W. Hunt and D. Reuss. Response of soil properties under C3 and C4 perennial grasses to elevated CO_2 and climate change.

An ecosystem experiment was conducted to determine the influence of climate change and elevated CO_2 on the shortgrass steppe. Large cores dominated either by *Bouteloua gracilis* (C4) or *Pascopyrum smithii* (C3) were removed from the prairie and exposed for two growing seasons to all combinations of ambient or elevated (700 ppm) CO_2, normal or elevated (+4°C) temperatures and three levels of annual precipitation (150, 250 and 360 mm; the site average is 310 mm) in large growth chambers.

We did not expect to see significant differences in total soil organic C and N over this short period, and we observed none. However, we were able to detect significant ($P<0.05$) differences among treatments based upon measurements that detect pools of organic C and N that have faster turnover times than the total soil organic matter. Carbon mineralization, based upon respiration of a 20 day soil incubation, was slightly higher (6%) at increased compared with normal temperatures. Intermediate and high levels of precipitation resulted in greater respiration than low levels at the end of the first growing season, but these differences disappeared by the end of the experiment. Elevated CO_2 resulted in an increased C respiration of 19% in soil under *P. smithii* and only 4% under *B. gracilis* (Table 1). N mineralization was unaffected by elevated CO_2 while increased temperature caused a slight increase for soil under *P. smithii* but a slight decrease for *B. gracilis*. Differences in mineralization rates for precipitation treatments were similar at the end of season one, but by the end of season two the rate was greatest with the least precipitation. In almost all cases, the N mineralization rates were greater for the second, compared with the first ten days of the incubation. In one case, the C/N of mineralization was reduced from 55 to 19 between these periods. These results suggest that N immobilization may play an important role in determining the observed net N mineralization rates. This observation seems to be specifically true for treatments with elevated CO_2.

Interpretation of these results is complicated because net changes in soil organic matter pools are the result of changes in plant inputs and decomposition losses, both of which have responded to our experimental global change scenarios (Hunt et al., submitted). Our short-term results suggest that global climate change is likely to significantly influence soil organic matter levels and nutrient availability in the shortgrass steppe. We require further analysis of our plant and soil data to make more explicit statement of the controlling mechanisms.

Table 1. Effects of elevated CO_2 on soil respiration (species x CO_2, significance, P=.007) ($\mu g\ CO_2$-C $g^{-1}\ d^{-1}$).

Plant Species	CO_2 Normal	CO_2 High
P. smithii	20.4	24.2
B. gracilis	12.2	12.8

Table 2. The effects of precipitation on N mineralization (μg N g^{-1} soil d^{-1}) (date x precipitation, significance, P=.02).

Precipitation	End of Season 1	End of Season 2
low	.61	.95
medium	.57	.77
high	.59	.76

Hunt, H.W., E.T. Elliott, J.K. Detling, J.A. Morgan and D.-X. Chen. submitted. Responses of a C3 and a C4 perennial grass to elevated CO_2 and climate change. Global Change Biology.

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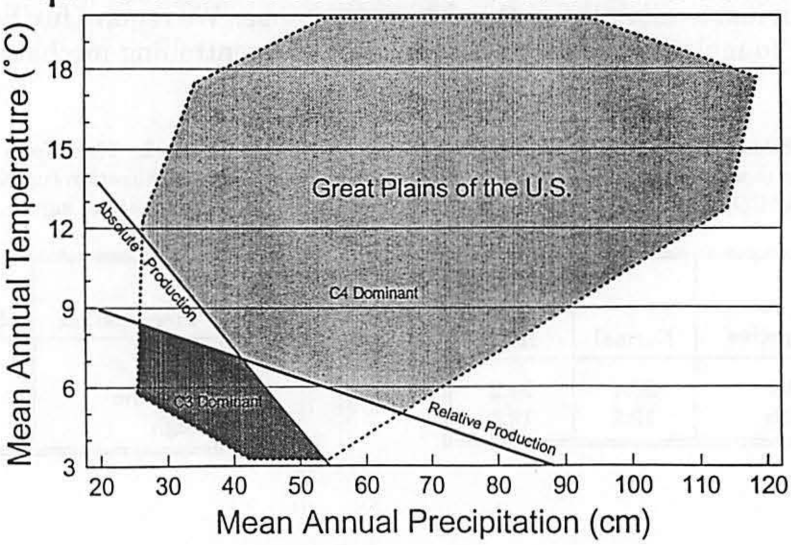
Epstein, H.E., W.K. Lauenroth, I.C. Burke and D.P. Coffin. Productivity of C_3 and C_4 functional types in the Great Plains of the U.S. College of Natural Resources, Colorado State University, Fort Collins, CO 80523.

We analyzed the productivity of C_3 and C_4 plant functional types throughout the Great Plains of the United States with respect to three environmental factors: temperature, precipitation and soil texture. Productivity of functional types were collected from Soil Conservation Service (SCS) rangeland survey data. Climate data were interpolated from USGS weather stations throughout the region. Soil texture data came from SCS State Soil Geographic (STATSGO) databases. A geographic information system was used to spatially integrate the three data sources. With a dataset of spatially random points, we performed stepwise regression analysis to derive models of the relative and absolute production of C_3 and C_4 grasses in terms of mean annual temperature (MAT), mean annual precipitation (MAP), and percentage sand, silt and clay.

MAT, MAP and soil texture explained between 67% and 81% of the variation in the relative and absolute production of C_3 and C_4 grasses. Production of C_3 grasses was negatively related to MAT and SAND, and positively related to CLAY. Relative production of C_3 grasses declined with MAP, while absolute production increased slightly with MAP. Production of C_4 grasses was positively related to MAT, MAP and SAND, and negatively related to CLAY. MAP was the most explanatory variable in the model for C_4 absolute production. MAT was the most explanatory variable in the three other models.

Equivalent Production of C3/C4 Grasses



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Fitzgerald, J. P., L. Dent, M. Link, and B. Roell. Ecology of the swift fox, Vulpes velox, in northern Weld County.

Research was recently started on the ecology of swift foxes on the CPER site. The swift fox is a small, prairie adapted canid that has been petitioned for listing under the Endangered Species Act (ESA). The U.S. Fish and Wildlife Service is in the process of completing its decision on whether or not to list the species. Objectives of this study include: 1. Capturing, radio-collaring, and monitoring movements and population dynamics of a minimum of 60 swift foxes to be captured on or within 40 km of the CPER; 2. Documenting frequency of fox use of different habitat types including shortgrass prairie, saltbush communities, fallow lands, and cropped dry land areas; 3. Investigating interactions between swift foxes and coyotes, and swift fox predation on the mountain plover (a ground nesting bird also petitioned for listing under ESA); 4. Evaluating techniques for estimation of swift fox population density and/or trend. 5. Comparing present swift fox population status and distribution with results obtained from swift fox surveys in the late 1970's and early 1980's on the Pawnee National Grassland by the senior author and his students. Since mid October a total of 30 swift foxes (12 adult males, 4 male pups, 8 adult females and 6 female pups) have been captured and radio-collared. All animals have been captured on CPER lands or on national grasslands to the south of the area. The total area trapped covers 96 square km. This represents the highest concentration of swift foxes ever reported. Three radioed animals, two adult males, and a juvenile female, have been found dead. One from coyote depredation, one road-killed, and one from undetermined causes. Some individuals have moved over 6 km from their sites of capture. Others are staying within 1-2 km of their den sites. Locations where foxes were trapped, and sites of dens being used by radioed foxes are concentrated on rolling, short-grass prairie uplands, with fewer animals using the saltbush communities and rougher terrain on the southeastern border of the site. Individuals are beginning to pair bond in preparation for the mating season which starts in late December. Trapping and radio-collaring of an additional 30 animals will begin in January on U.S. Forest Service lands to the east of the CPER.

USDA UV-B Monitoring Program

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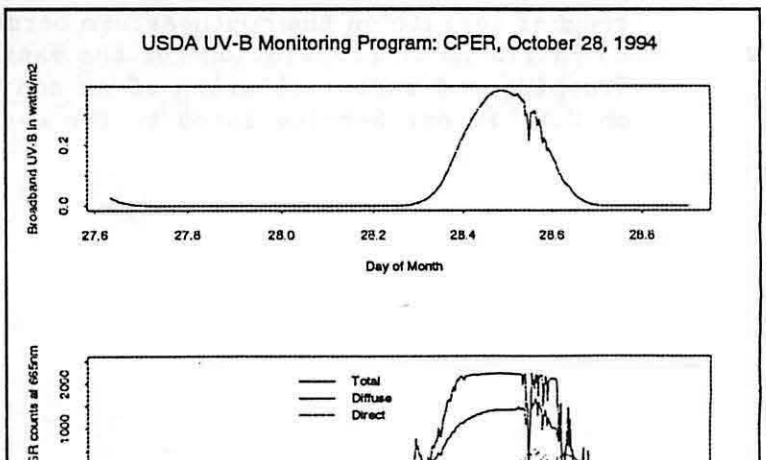
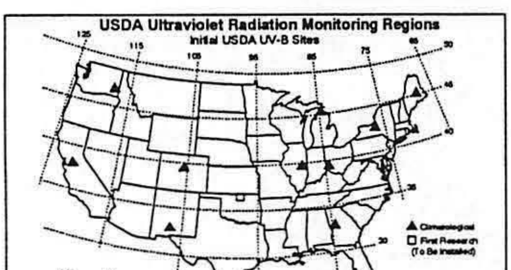
Gibson, James H., David S. Bigelow, William S. Durham. USDA UV-B Radiation Monitoring Program

The U. S. Department of Agriculture (USDA) has a responsibility to agriculture to assess the potential effects of UV-B radiation on agricultural crops and forests. To meet this responsibility, data on surface UV-B radiation is essential to establish both the climatology and long-term trends. It is also necessary to support programs related to assessment of UV-B effects on human health, ecosystems, and materials, as well as supporting atmospheric science research, model development and providing ground truth for satellite measurements. To meet these objectives, two networks will be necessary - research and climatology. The climatology network will require a large number of sites deployed across the U.S. but will not require the sophisticated high resolution spectroradiometers to be deployed at the research sites. This two phase approach will meet the need for high resolution spectral data, and at the same time provide UV-B climatology over broad geographic regions to support regional assessments of the potential impacts on agriculture and forests.

Currently the monitoring site at the CPER is one of 10 sites in the climatology network (see map below). The site has been operational since February 1994 and UV-B data is available from the UV-B program office in the NREL. A sample of the data for October 28 is shown on the graph displayed below. In addition to UV-B data in shown in the upper graph, the sites are instrumented with a shadow band radiometer which provides total horizontal, direct normal, and diffuse radiation at seven wavelengths in the visible and near infrared. In the example shown in the lower graph below, the wavelength is 665 nanometers. It is noted that the direct normal is larger than the diffuse since the reading is corrected for as though the meter were looking directly at the sun. The primary use of this data is to determine the aerosol optical depth which is a measure "haziness" on clear days and provides information on cloud cover. The site at the CPER is also serving as reference site for instrument calibration and evaluation for the network.





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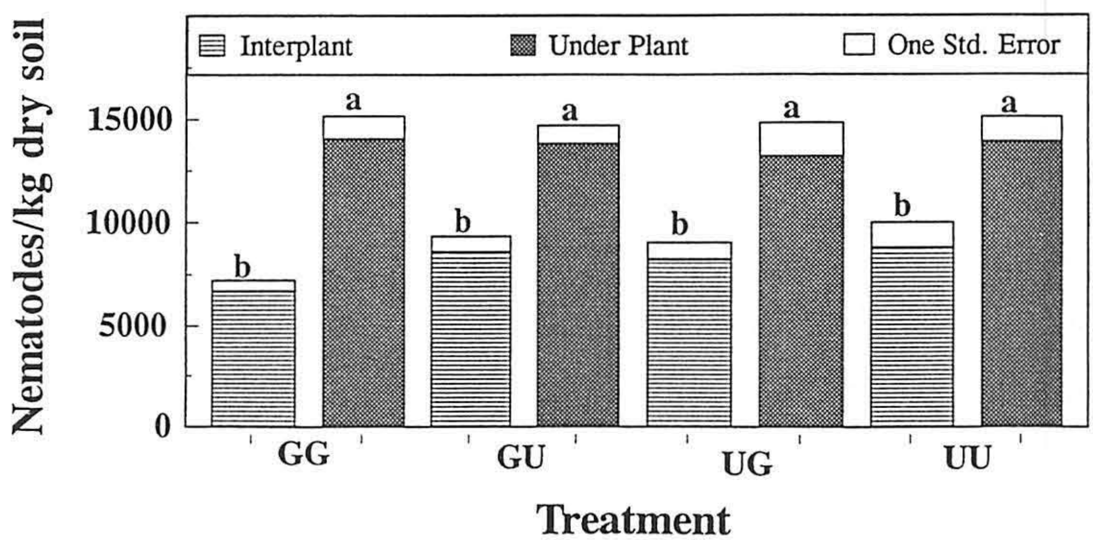
Huang, S. P. , Freckman, D. W., Easter, M., Niles, R. K. and Kratz, M. J. Nematode biodiversity and grazing effects on nematode populations in the short grass steppe of CPER.

Nematode biodiversity and disturbance grazing on nematode communities are being studied on the most dominant grass species, *Bouteloua gracilis,* in the short grass steppe of the Central Plains Experimental Range (CPER). The experiment had four treatments [grazed since 1939(GG), grazed during 1939-1991 and ungrazed since 1992(GU), ungrazed since 1939(UU), ungrazed during 1939-1991 and grazed since 1992(UG)] with five blocks (Exclosures 5, 7, 11, 19 & 24) split into two subtreatments (under- and inter-plants) of six sampling points each. Total number of samples for the experiment was 240. Soil samples were taken with steel tubes (4.8 cm diameter) to 0-15 cm depth in October, 1994. Nematodes were extracted using the centrifugal flotation method and preserved in 2.5% formalin for counting the total numbers of nematodes. To determine nematode biodiversity, a portion (100-200 individuals) was randomly removed from each of the nematode samples and fixed for nematode identification at 10 x 40. The preliminary results show that the nematodes from CPER are classified to six orders (Tylenchida, Rhabditida, Isolaimida, Dorylaimida, Mononchida and Araeolaimida), 23 families, and about 40 genera, including five trophic groups (bacterial feeders, fungivores, omnivores, predators and plant parasites). Nematode populations were 41% larger in the underplant soils than in the interplant soils ($\underline{P} < 0.01$), with any differences among the four grazing levels having yet to be detected(see Figure). The soil water contents (av. 6.6 % ranged from 2.5 to 16.3 %) were not related to total nematode numbers ($r = 0.217$ for interplants, and 0.201 for underplants). Nematodes have been suggested to be sensitive to environmental changes. We continue to analyze this data to address the impact of disturbance and resilience of the nematode community under the influence of the above treatments at CPER.



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Kelly, Robin H., Ingrid C. Burke, and Kari Bisbee. Soil organic matter loss in the shortgrass steppe: role of plant removal.

We studied indices of active and total soil organic matter (SOM) over gradients of root density and disturbance age in order to make inferences about the role of plant inputs in SOM loss and maintenance in the shortgrass steppe. Cultivation of the plains has led to a reduction in SOM storage. Studies of losses due to cultivation are important, but they address the result of land-use change rather than specific components of the loss process. Because inputs and outputs are altered through cultivation, losses in SOM cannot be attributed to a specific pathway. By studying SOM in naturally-occurring bare areas, we were able to attribute a portion of loss directly to the absence of plants. Western Harvester ant nests, the naturally-occurring bare areas we utilized, can be placed in approximate age classes based on morphology. This gradient in disturbance age allowed us to make some inferences about the temporal dynamics of SOM loss due to plant removal. In addition, we compared our results to the CENTURY soil organic matter simulation model to address some components of the underlying conceptual model. We found that active and total SOM indices decreased with decreasing root density and, to a lesser extent, with increasing disturbance age. Our results suggest that plant removal does not represent the dominant pathway of SOM loss due to cultivation.

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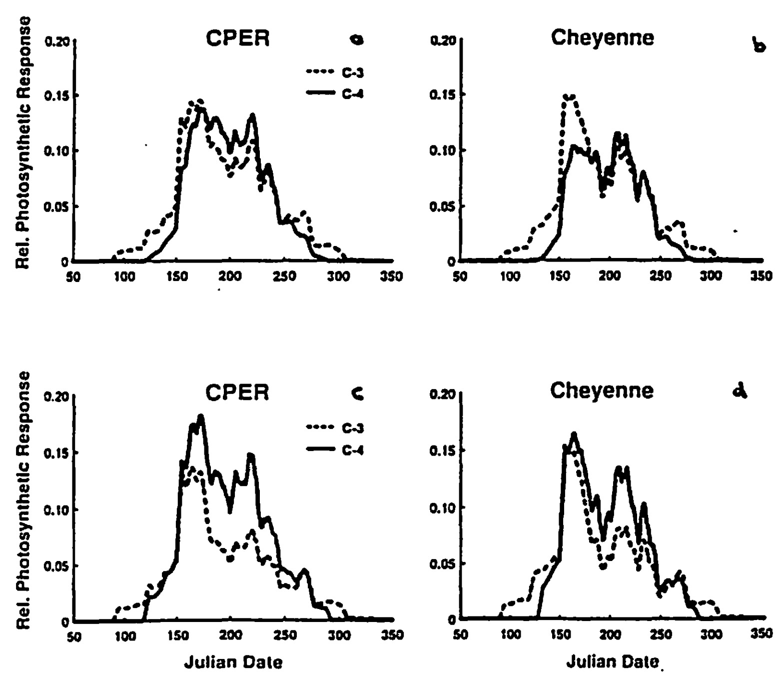
W.K. Lauenroth, D.P. Coffin, O.E. Sala, and W.J. Parton. Analysis of the distribution of C_3 and C_4 grasses between the Northern Mixed Prairie and the Shortgrass Steppe.

The boundary between the Shortgrass Steppe and the Northern Mixed Prairie is coincident with the state boundary between Wyoming and Colorado. The presence of a physiographic discontinuity at the boundary results in differences in climatic conditions on either side of the boundary, primarily air temperature. The presence of such a sharp boundary between two vegetation types provides an excellent opportunity to investigate the potential effects of climate change on vegetation structure. Our objectives were: (1) to analyze data from two sites, one on either side of the boundary, to evaluate differences in soil water availability as an explanation for the differences in dominance by C_3 and C_4 grasses; and (2) to evaluate the potential alterations that climate change might cause in the present patterns of C_3 and C_4 grasses. Soil water availability was evaluated using a simulation model. Increasing air temperatures had a predictable effect on the thermal potential responses of the plant types at each site. C_3 plants experienced a more pronounced depression of activity by high temperatures under climate change than under nominal conditions. C_4 plants reached a greater maximum response level as a result of increased temperatures. From the perspective of temperature alone, climate change made both sites more favorable for both plant types. The effect of altered temperatures on soil water availability at each site was to make the sites slightly more favorable for C_3 grasses and substantially more favorable for C_4 grasses. The timing of peak responses during the spring-summer growing period was earlier for C_3 plants and later for C_4 plants at both sites. Integrating under the response curves at the CPER suggested that the total seasonal response of C_3 plants was increased only a small amount by increased temperatures, while the response for C_4 plants was increased a large amount. The responses of C_3 grasses was increased approximately 5% at each site. The response of C_4 grasses was increased 20% at the CPER and 30% at Cheyenne.

Figure. Relative photosynthetic responses of C_3 and C_4 species to current conditions (a and b) and to climate change conditions. Climate change consisted of increased temperatures.



1995 CPER SYMPOSIUM

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Lindquist, Mark D., Paul Stapp, and William K. Lauenroth. Monitoring studies of small mammal populations on the Shortgrass Steppe Long-Term Ecological Research site.

As part of the Shortgrass Steppe Long-Term Ecological Research (LTER) Program, we initiated a program in 1994 to estimate the abundance of populations of rodents and lagomorphs on the Central Plains Experimental Range (CPER) in north-central Colorado. The goal of this research was to establish a program to monitor population trends of these mammals, which could be used to provide baseline information for experimental work on the CPER site and for future comparative studies among LTER stations from different ecological regions. The objective of this poster is to stimulate interest in and discussion of our monitoring programs, and to describe results from the first year of these efforts.

Population densities of nocturnal rodents are estimated each spring and summer by live-trapping for four consecutive nights on six 3.14-ha trapping webs. Webs are located on three upland sites dominated by perennial grasses (*Bouteloua gracilis*, *Buchloe dactyloides*), and on three lowland sites with abundant shrub cover (*Atriplex canescens* and numerous half-shrubs). To estimate densities of lagomorphs, we count the number of lagomorphs observed along a 32-km route of pasture and county roads for one night in January, April, July, and October. Population densities of rodents and lagomorphs are calculated using estimators based on distance sampling theory.

Our preliminary analyses indicated that the diversity and abundance of rodents was much higher on shrub-dominated lowlands than on upland sites (Table 1). Although eleven species of nocturnal rodents are known to be present on the CPER, most captures were of four species (deer mouse, *Peromyscus maniculatus*; northern grasshopper mouse, *Onychomys leucogaster*; Ord's kangaroo rat, *Dipodomys ordii*; western harvest mouse, *Reithrodontomys megalotis*) and only northern grasshopper mice were captured consistently on upland webs. Thirteen-lined ground squirrels (*Spermophilus tridecemlineatus*) were present on both upland and lowland webs, but their populations currently are not monitored. Desert cottontails (*Sylvilagus audubonii*) and black-tailed jackrabbits (*Lepus californicus*) were the most frequently-sighted lagomorphs during roadside counts. Plans for additional monitoring efforts will be discussed.

Table 1. Mean (standard error) of numbers of individuals of rodents captured on six 3.14-ha trapping webs on the CPER during four consecutive nights of live-trapping in September 1994.

SPECIES	UPLAND WEBS (3)	LOWLAND WEBS (3)
Northern grasshopper mouse	4.67 (0.88)	7.67 (1.33)
Deer mouse	0.67 (0.33)	8.67 (2.73)
Ord's kangaroo rat	0	7.33 (1.86)
Western harvest mouse	0	3.33 (2.85)

SUMMARY FORM: 1995 CPER SYMPOSIUM

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Frasier, Gary W., Gerald Schuman, Jean Reeder, Pam Lyman, and Dennis Mueller. Hydrologic Impact of Animal, Municipal and Industrial Waste on Rangelands.

A study is being conducted to evaluate the hydrologic effects of applying animal, municipal, and industrial wastes on native shortgrass rangeland sites in the Central Great Plains. This report is a companion paper to a study investigating the impact of the waste applications on rangeland soils and vegetation. The waste materials used in the studies were (1) fresh animal waste, (2) composted animal waste, (3) composted sewage sludge, (4) phosphogypsum (an industrial waste product) and (5) control (no treatment). The waste materials were applied at a rate of 10 tons per acre to individual 10 x 30 ft. plots. The rotating boom rainfall simulator was used to measure the runoff water quantity. One half of the plots were evaluated within 3 days of application in May 1993. All the plots were evaluated in August 1993. At the time of application (May 1993), the equilibrium runoff from the fresh animal waste and the composted sewage sludge treatments were less than from the control. The runoff from the other treatments were not different than the control. In August the runoff from the fresh animal waste (38%) and composted sewage sludge (42%) was less than the control (62%) but the phosphogypsum was greater (75%). These results show that one cannot assume that the surface application of these materials will automatically improve water infiltration.

Equilibrium runoff rates (%)(mean ± std.div.) from a 45 minute rainfall simulator run.

	Treatment				
Evaluation Period	Phosphogypsum	Fresh Animal Waste	Composted Animal Waste	Composted Sewage Sludge	Control
	(%)	(%)	(%)	(%)	(%)
May	52±8	38±3	43±15	45±2	56±12
August	75±15	38±6	58±23	42±12	62±13

SUMMARY FORM: 1995 CPER SYMPOSIUM

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Scholes, M.C., R.E. Martin, A.R. Mosier, W.J. Parton, and D.S. Ojima. Water and Temperature Controls on NO and N_2O Soil Fluxes from Denitrification Shortgrass Steppe.

Soil fluxes of nitrous oxide (N_2O), nitric oxide (NO), carbon dioxide (CO_2) and methane (CH_4) were measured during the summer of 1994 in a hsortgrass steppe soil at the Central Plains Experimental Range, Colorado. Five sites with differing textures, landscape positions and land-uses were chosen to give a range of water-filled pore spaces (WFPS) and substrate availabilities. Simulated light and heavy rain storms resulted in large and rapid responses in NO (6-100 ngN/m^2)/s) and N_2O (0-50 μgN/m^2/hr) flux rates. Maximum flux rates were obtained in 30 mins to 4 hrs after wetting. NO flux rates were generally 30 times higher than N_2O rates. These responses were short-lived and dropped back to pre-wetting levels within a few days. The magnitude of the NO flux appeared to be related to the substrate availability and was well correlated with soil CO_2 fluxes. The duration of the flux was more closely controlled by the WFPS. The NO flux rate peaked at approximately 35% WFPS with the N_2O fluxes continuing to increase with increased WFPS. Temperature effects on NO fluxes became more pronounced as the WFPS increased.

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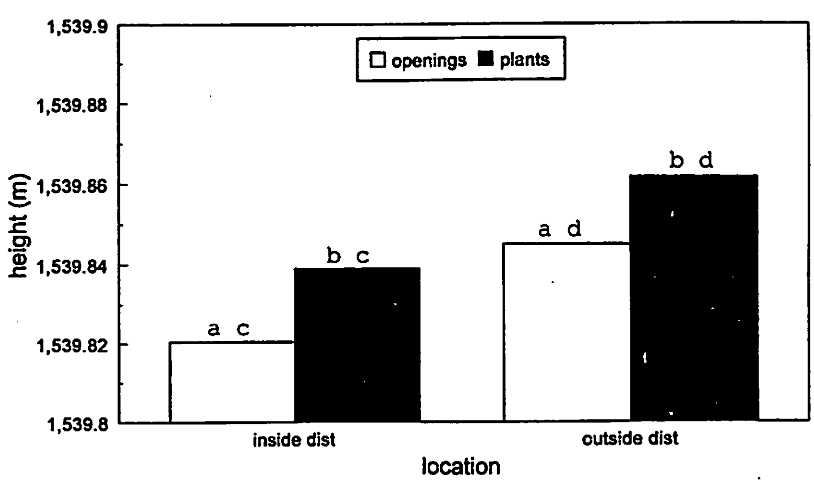
Martinez-Turanzas Gustavo A. and Debra P. Coffin. EFFECTS OF DISTURBANCE SIZE AND SOIL TEXTURE ON MICROTOPOGRAPHY IN A SHORTGRASS COMMUNITY.

Our objective was to evaluate the effects of disturbance size and soil texture on the microtopography of the landscape for a shortgrass plant community at the CPER. Disturbances of three sizes (50,- 100,- 150- cm-diameter) created in 1984 to 1985 at two sites differing in soil texture (sandy loam, clay loam) were used to evaluate the recovery of the small-scale pattern of bunchgrasses and bare soil openings. The disturbance plots were not manipulated after being created, therefore vegetation recovery occurred through time until the microtopography was measured in 1993. A laser surveying instrument was used to measure the heights of crowns of individual plants of the dominant species, the perennial bunchgrass *Bouteloua gracilis* ([H.B.K.] Lag. ex Griffiths) and bare soil openings located within each disturbance and in the surrounding undisturbed landscape.

Our results indicate that crown heights of plants were significantly higher than bare soil openings both for the undisturbed landscape and inside each disturbance. The difference between crown heights and bare soil openings was similar for both locations indicating that the pattern of the landscape had recovered within 8 years. However, complete recovery to the predisturbed state had not occurred since in all cases, crown heights and bare soil openings were significantly lower on disturbed areas than for the corresponding locations on the undisturbed landscape. These differences indicate the net loss of soil material on disturbed areas through time, especially for interspaces, and the accumulation of material under plants.
Disturbance size and soil texture were important to the development of the microtopography inside of the disturbed areas. In general, soil erosion increased as disturbance size increase and was more pronounced on fine than coarse-textured soils.



Average height (in meters above sea level) of plants and bare soil openings inside and outside of disturbance.
Bars without letters in common are statistically different ($p<0.05$)
The letters a and b denote a significance between plant and bare soil openings within location and the letters c and d denote a significance between location and within plantand opening microsite.

SUMMARY FORM: 1995 CPER SYMPOSIUM

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McEwen, Lowell C. and Brett E. Petersen. Effects of Grasshopper Insecticides on Wildlife in a Rangeland IPM System

Aerial spraying for range grasshopper control averages >400,000 ha yearly and has exceeded 5,000,000 ha in an outbreak year. Ecologically harmful organochlorines such as aldrin, dieldrin, heptachlor and toxaphene were formerly sprayed. An IPM system is being developed by USDA, APHIS that utilizes less persistent/less toxic chemicals (malathion and carbaryl) and emphasizes small preventive treatments. Biologicals (Nosema locustae; Beauveria bassiana) and other more selective materials, such as diflubenzuron, are being tested. Direct mortality of nontarget terrestrial wildlife is no longer of concern but fish and other aquatic life are susceptible to direct overspray. Current research investigates possible indirect effects (loss of insect food base) and sublethal effects on nontarget species. Sublethal effects of malathion and carbaryl on terrestrial vertebrates appear minor based on cholinesterase studies. Indirect effects are generally not significant because birds and small mammals switch to other insect food when grasshoppers are reduced. Grasshopper control in conjunction with natural food restrictions (such as drought-related) might have greater impact on wildlife. Biologicals tested have no toxicity to wildlife but are more expensive and less effective for grasshopper control. They are used primarily in sensitive areas such as near Endangered Species habitat. Carbaryl bait is the safest chemical control method. The amount of chemical used is much lower than in liquid sprays, the bait is more pest-specific, and dermal and inhalation exposure of nontarget wildlife are eliminated.

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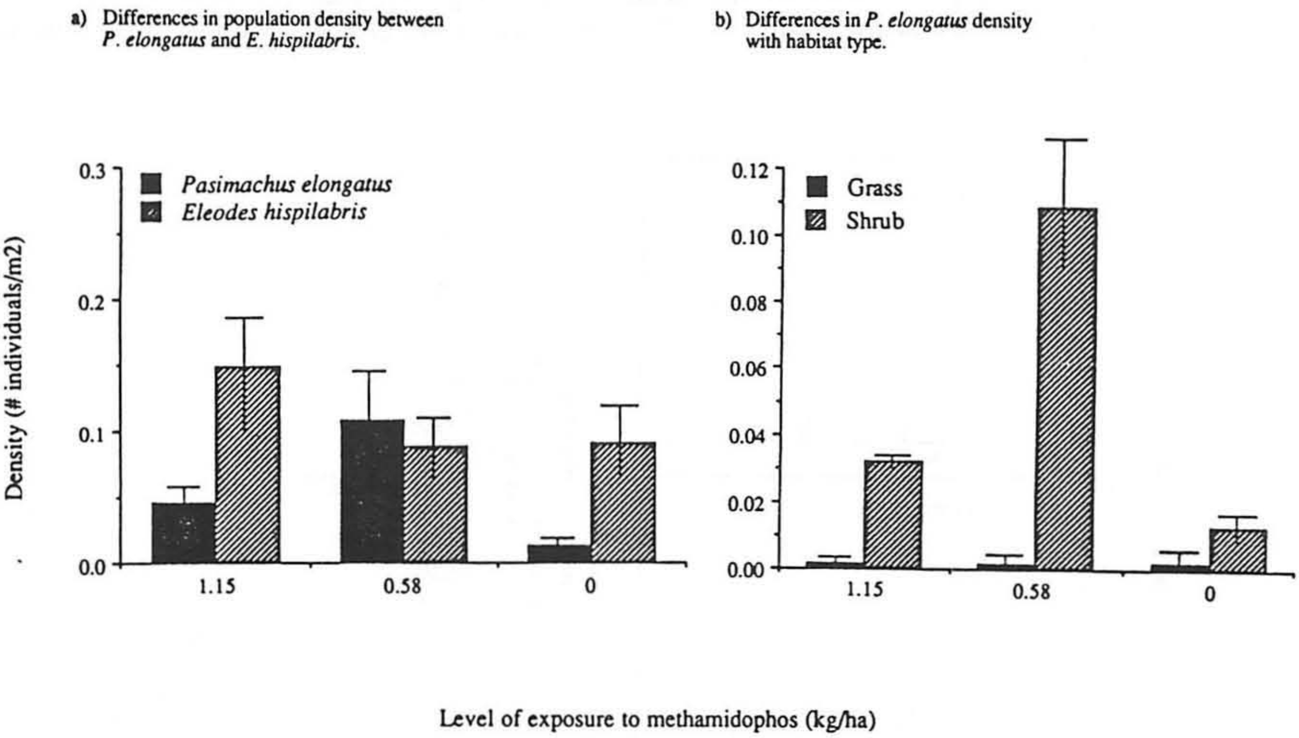
McIntyre, Nancy E. Effects of a methamidophos application on *Pasimachus elongatus* LeConte (Coleoptera: Carabidae): An update after six years.

Population densities of a predatory ground beetle, *Pasimachus elongatus* LeConte (Coleoptera: Carabidae), were examined at the Central Plains Experimental Range, Colorado. Using a pitfall trapping web design, I analyzed density estimates dating prior to an application of the insecticide methamidophos (1988) and three beetle generations afterwards (1994) to address the following question: Are current population densities of *P. elongatus* in areas exposed to methamidophos in 1988 equal to those not exposed in 1988? In addition, beetle densities in grass- and shrub-dominated areas were compared to answer the following question: How do population densities of *P. elongatus* vary with habitat type in methamidophos-exposed and non-exposed areas? This work updates Ebert and Kondratieff's (1992) findings that *P. elongatus* population densities decreased after methamidophos applications. Lingering differences in *P. elongatus* densities were found among areas differing in methamidophos exposure; these differences were attributed to differences in abundances of herbivorous prey species (e.g. *Eleodes hispilabris* [Tenebrionidae]) in these areas. Differences in population densities with habitat type were also present.



SUMMARY FORM: 1995 CPER SYMPOSIUM

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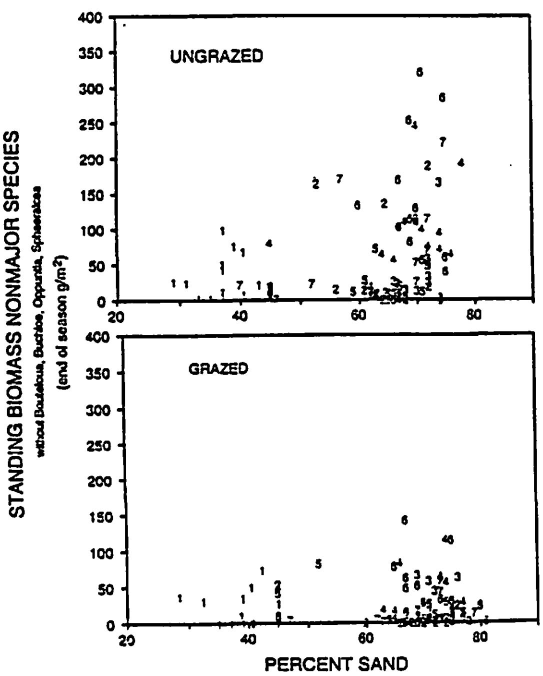
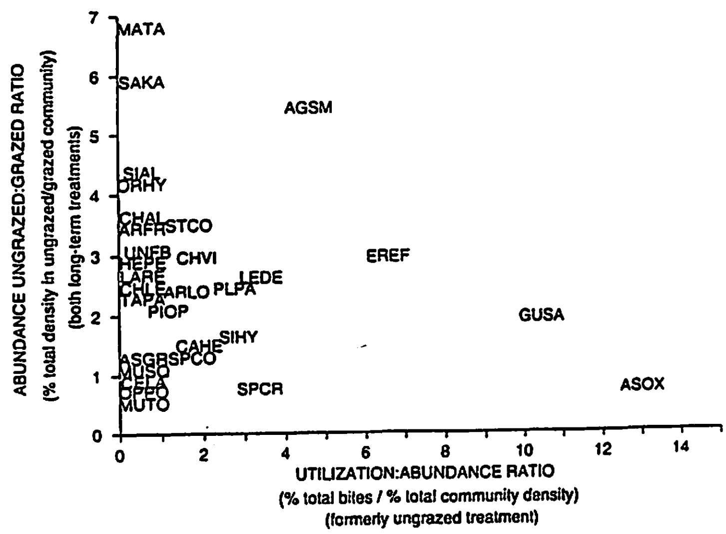
Milchunas, Daniel G. and William K. Lauenroth. Consistency in plant community response to grazing and protection.

Only a few of the hundreds of 'fence-line' grazed-ungrazed studies in the literature utilize a well-replicated design, and their conclusions suggest a high degree of inconsistency in plant response from site-to-site. We examined long-term grazed and protected shortgrass steppe at seven paired sites up to 10 km apart in relation to soil texture, landscape position, and utilization by herbivores. Within-site variability in soil texture was as great as that between sites, and the small-scale patch-to-patch variability explained plant response better than variability in means from site to site. Greater plant diversity in patches of coarse-texture soil in ungrazed treatments was not evident in grazed treatments; grazing tended to smooth small-scale environmental variability. Herbivore preference for a plant species (utilization/abundance) in treatments newly opened to grazing was not a good indication of its abundance in long-term grazed compared to ungrazed communities, and increases or decreases of a particular species were not always consistent across sites. The intensity of grazing at a particular site also shifted from year to year. In general, species of intermediate abundance, rather than the dominant or rare species, were most negatively impacted by grazing.





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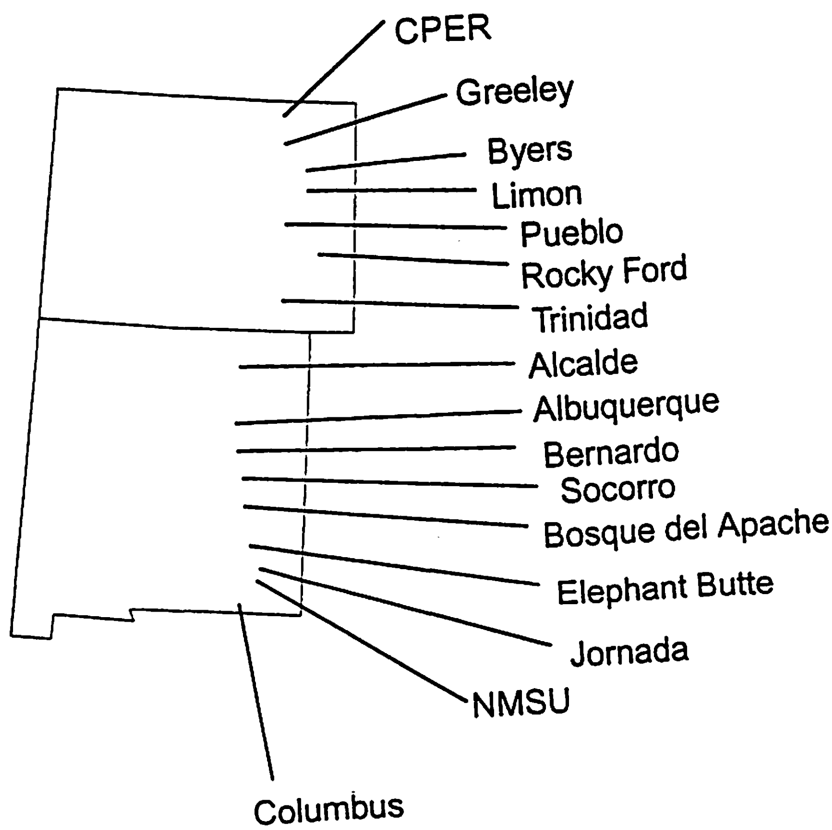
Minnick, Tamera J.[1], and Debra P. Coffin[1,2,3] . [1]Graduate Degree Program in Ecology, [2]Dept. of Rangeland Ecosystem Science, [3]Natural Resource Ecology Laboratory, Colorado State Univ., Ft. Collins, CO 80523. PREDICTING GERMINATION AND ESTABLISHMENT OF *BOUTELOUA GRACILIS* AND *BOUTELOUA ERIOPODA* ACROSS AN ENVIRONMENTAL GRADIENT USING A SOIL-WATER MODEL

Our objective is to evaluate the rates of germination and establishment of *Bouteloua gracilis* and *Bouteloua eriopoda* along an environmental transect from the Central Plains Experimental Range in northern Colorado to southern New Mexico. We used previously published work for the recruitment criteria for *B. gracilis*. We estimated recruitment criteria for *B. eriopoda* by comparing data on years of seedling establishment from long-term quadrats at the Jornada Experimental Range to predicted years of seedling establishment. To predict seedling establishment, we used long-term climatological data from the Jornada in SOILWAT, a model which simulates daily soil water in the canopy and soil layers. We used 25 years of climatic data from weather stations at 16 sites in Colorado and New Mexico to produce 5000 years of weather data for each site using a Markov weather generator. Using the above criteria for the germination and establishment of *B. eriopoda* and *B. gracilis*, we estimated rates of establishment for each species at each site using the SOILWAT simulation model. These rates were compared with the abundance of each species at each site to determine if establishment rates could explain the distribution and abundance of the two species.



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Dan LeCain and Jack Morgan. Photosynthetic and Growth Responses of NAD-ME and NADP-ME type C_4 Grasses Grown at Elevated CO_2.

Atmospheric [CO_2] have been rising for more than a century, and is projected to continue rising well into the 21st century. Despite conventional wisdom which suggests C_4 photosynthesis is presently CO_2-saturated, we found substantial stimulations in photosynthesis of the C_4 grass *Bouteloua gracilis* when [CO_2] was raised above current atmospheric levels (Morgan et al., 1994). Since C_4 grasses are an important component in numerous grasslands worldwide, it is important to understand the degree to which continued increases in atmospheric [CO_2.] will affect their photosynthesis and growth.

Based on differences in bundle-sheath anatomy and biochemistry, we hypothesized that photosynthesis and growth of C_4 grasses from different C_4 - acid decarboxylation groups would respond differently to CO_2.. Three native Great Plains species each of the NAD-ME and NADP-ME subgroups were grown at 350 and 700 μL L CO_2 with abundant water and fertilizer. Leaf photosynthesis of all six species was enhanced when [CO2] were raised above current ambient levels. However, only the NADP-ME plants exhibited positive growth responses to CO_2 enrichment. Species with increased growth also had higher leaf carbohydrate concentration and lower leaf nitrogen concentrations. These results suggest that differences may exist among C_4 grasses in their ability to respond to increases in atmospheric [CO_2], and that CO_2-induced changes in growth and tissue nutrient concentrations are not necessarily confined to plants with the C_3 pathway.

TOTAL DRY WEIGHT (g)

CO_2	NAD-ME	NADP-ME
350 μL L^{-1}	8.8	3.9
700 μL L^{-1}	8.8	7.0
P > f	.99	.04

LEAF NITROGEN (g kg^{-1})

CO_2	NAD-ME	NADP-ME
350 μL L^{-1}	34.4	27.0
700 μL L^{-1}	33.5	24.3
P > f	.45	.007

NON-STRUCTURAL CARBOHYDRATES (g kg^{-1})

CO_2	NAD-ME	NADP-ME
350 μL L^{-1}	182	107
700 μL L^{-1}	183	207
P > f	.97	.001

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Mosier, Arvin R., Delgado, J.A., Cochran, V.L., and Valentine, D.W.
Methane and Nitrous Oxide Fluxes in Grasslands in Alaska, Colorado and Puerto Rico.

Methane and N_2O flux was measured weekly in N-fertilized and unfertilized grasslands near subarctic Fairbanks, AK, temperate Fort Collins, CO and tropical Mayaguez, PR, beginning in 1992, 1990 and 1992, respectively. Long term effects of land use change and N-fertilization are evident within the Colorado short grass steppe where both decrease uptake of atmospheric CH_4 by about 30% and increase N_2O emission 2 to 3 times. In managed grasslands in both Alaska and western Puerto Rico, no long-term N-fertilization effects on CH_4 uptake were observed. Nitrous oxide emissions are stimulated for over a decade from a single application of N in the temperate grassland while stimulation of N_2O production is pronounced but short-lived in both the subarctic and tropical grasslands. Year around CH_4 consumption rates averaged about 40 μg CH_4-C m^{-2} hr^{-1} in the native Colorado grassland compared to about 5 in Puerto Rico and average summer consumption rates of 16 in Alaska. Nitrous oxide emissions averaged 1.9 and 2.1 μg N m^{-2} hr^{-1} in unfertilized sites and 6.1 and 3.4 from fertilized sites in Alaska and Colorado, respectively. The N_2O emissions from the unfertilized Puerto Rican sites averaged about 17 μg N m^{-2} hr^{-1} and increased 2 to 3 times with fertilization.

SUMMARY FORM: 1995 CPER SYMPOSIUM

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Frasier, Gary W., Dennis Mueller, Pam Lyman, Gerald Schuman, and Richard Hart. Effects of Livestock Grazing Reduction on Infiltration and Runoff from Native Shortgrass Rangelands.

A rotating boom rainfall simulator was used to evaluate the effects of removing cattle from a native shortgrass rangeland site in the Central Great Plains on infiltration and runoff. Study sites included three pastures which had been grazed at the same intensities for over 50 years. After one year there were changes in the initial runoff ratio on the area which had been heavily grazed but no changes were evident in the final runoff ratios after two years. These results indicate that changes in the infiltration parameters of the surface soil layers occur within two years after removal of cattle grazing but no changes occurred at the deeper soil depths which affect long-term equilibrium infiltration. Final runoff rates changed on the light and moderate grazed areas. Biomass on these lighter grazed areas was able to increase rapidly and increase water infiltration rates when grazing pressure was removed.

Equilibrium runoff rates (%)(mean ± std.div.) from rainfall simulator dry run, wet run and wet-wet run.

	Grazing Intensity		
Year	Light (%)	Moderate (%)	Heavy (%)
Dry run			
1992	11±9	18±15	61±7
1993	18±16	25±13	52±7
1994	4±2	6±4	30±7
Wet run			
1992	11±9	30±16	61±7
1993	14±10	35±14	42±6
1994	5±5	19±8	35±5
Wet-Wet run			
1992	33±7	64±15	63±2
1993	41±11	58±20	64±4
1994	18±10	41±12	59±3

SUMMARY FORM: 1995 CPER SYMPOSIUM

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Parton, W.J., D.S. Ojima, A.R. Mosier, D. W. Valentine, and D.S. Schimel. General Model of N_2 and N_2O Fluxes from Nitrification and Denitrification.

A general model was developed to simulate N_2 and N_2O fluxes from nitrification and denitrification. N_2O flux from nitrification are functions of the soil water filled pore space (WFPS), soil temperature and the maximum nitrification rate (soil specific parameter). The effect of WFPS on nitrification is a function of soil texture with the optimum value for nitrification occurring at higher WFPS values for fine textured soils. Total soil N_2 and N_2O gas fluxes from denitrification are a function of the soil NO_3 level, soil respiration rate at 0.6 WFPS (index of available soil C) and soil WFPS. The maximum nitrogen gas flux from denitrification is calculated as the minimum of the soil respiration and soil NO_3 functions and reduced by WFPS function. Denitrification rates decrease as WFPS decreases below 0.9, with the rate decreasing most rapidly in fine textured soils. The ratio of N_2:N_2O gas fluxes from denitrification is a function of soil respiration rate, soil NO_3 level and soil WFPS. The highest N_2:N_2O ratios occur for soils with low soil NO_3 levels, and high values of soil respiration and WFPS. The model was tested using both field and laboratory gas flux data.

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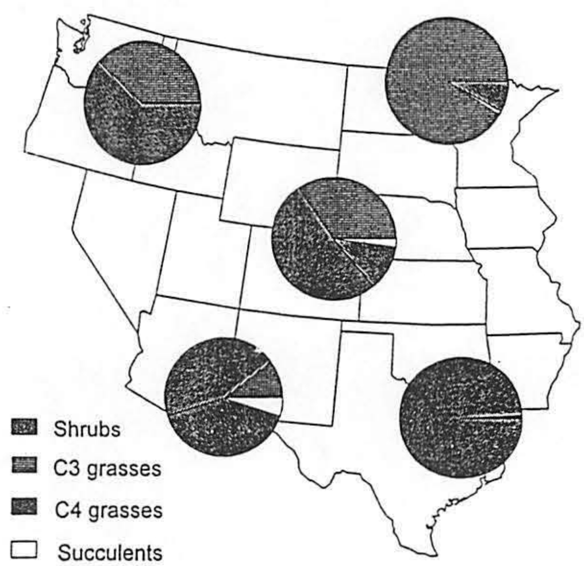
Paruelo, José M., and William K. Lauenroth.Climatic controls of the distribution of plant functional types in grasslands and shrublands of North America.

We analyzed the distribution of the relative abundance of plant functional types in the geographic and climatic space over grassland and shrubland areas of central North America. From actual vegetation data for 73 sites spread between 93° and 120° west longitude and 29° and 52° north latitude, we estimated the relative abundance of 5 functional types: shrubs, C_3 grasses, C_4 grasses, forbs, and succulents. Study sites corresponded to areas with low human impact.

Latitude and longitude explained a substantial portion of the variability of the distribution of shrubs, C_3 grasses, and C_4 grasses (55%, 46%, and 62% respectively). Along a given longitude, C_3 grasses increased with latitude. As one moves westward there is a replacement of C_4 grasses by shrubs. The relative abundance of C_4 grasses was greatest at southern latitudes and eastern longitudes. Succulents showed a marginal decreasing trend with latitude. For forbs no relationship with geographic variables was detected.

Precipitation and its distribution are important controls, in addition to temperature, of the distribution of C_3 and C_4 grasses. C_4 grass distribution was positively related with three climatic variables: mean annual precipitation, mean annual temperature, and the proportion of the precipitation falling in summer. These variables accounted for 66% of the total variability of this functional type. C_3 grass abundance decreased with mean annual temperature. For grasslands, the abundance of C_3 grasses also increased with the proportion of the precipitation falling during winter. The amount of the variability in the relative abundance of C_3 grasses explained by climatic variables was higher for grassland sites (47%) than for shrubland sites (18%). Fifty five percent of the relative abundance of shrubs was explained by climate. The abundance of this functional type decreased with mean annual precipitation and increased with the proportion of water falling in winter.

Distribution of Functional types



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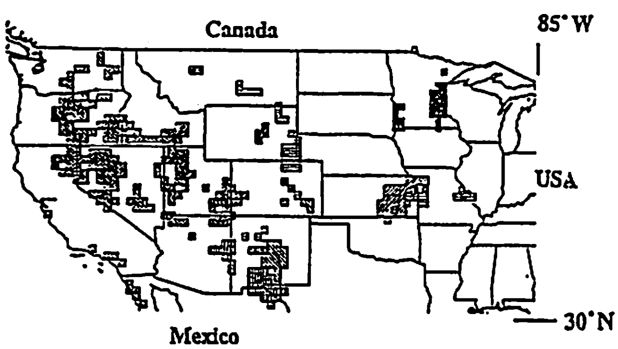
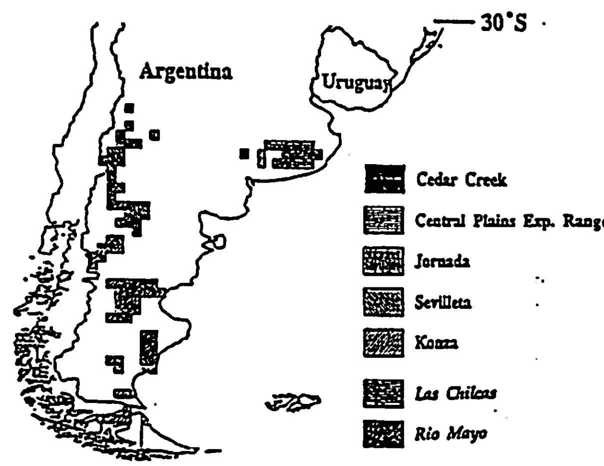
J.M. Paruelo, W.K. Lauenroth, H.E. Epstein, I.C. Burke, M.R. Aguiar and O.E. Sala.
Regional climatic similarities in the temperate zones of North and South America.

We performed an analysis of the climatic patterns of the temperte zones in North and South America using a global database of monthly precipitation and temperature. Three synthetic variables, identified by a Principal Component Analysis of the monthly data, were used: mean annual precipitation, mean annual temperature and the proportion of the precipitation falling during summer. We displayed the spatial gradient of the three variables by constructing a composite color raster image. We used a parallepepid classification algorithm to locate areas in both continents that are climatically similar to five North American Long Term Ecological Research sites and to two South Americanlong term ecological research sites. The same algorithm was used to identify areas in South America which are climatically similar to some of the major grassland and shrubland types of North America.
There is substantial overlap between the climates of North and South America. Most of the climatic patterns found in South America are well represented in North America. However, there are certain climates in North America that are not found in South America. An example is a climate with relatively low mean annual temperature and high summer precipitation. The climatic signatures of three North American LTER sites (Cedar Creek, CPER and Sevilleta) were not found in South America. The climatic signatures of two LTER sites (Konza and Jornada) had some representation in South America. Two South American research sites (Rio Mayo and Las Chilcas) were well represented climatically in North America. The climates of six out of seven selected North American grassland and shrubland types were represented in South America. The northern mixed prairie type was not represented climatically in South America. Our analysis suggests that comparisons of North and South America can provide a powerful test of climatic control over vegetation.





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Schuman, G.E., G.F. Frasier, J.D. Reeder, and R.H. Hart. Utilization of municipal, industrial and animal wastes on semiarid rangelands.

In recent years, cities and industries have begun to consider rangelands as potential sites for disposal of municipal, industrial and animal wastes. Municipal sewage sludge and feedlot animal wastes have been successfully used as fertilizer and mulch on agricultural lands and reclaimed mined lands, but little information is available concerning the application of waste materials to rangelands where incorporation into the soil is not feasible. We applied industrial, municipal and animal wastes (22.4 Mg/ha) in May, 1993 to semiarid rangelands to determine short- and long-term changes in soil, plant and water quality properties. The study was established in pasture 11N of the Central Plains Experimental Range on short grass prairie (predominantly blue grama, *Bouteloua gracilis*). In 1993, aboveground plant production increased by 34-43% with applications of composted manure and composted sewage sludge, reflecting the additions of N and P from these amendments. Increases in production were due primarily to increases in warm season grasses, and secondarily to increases in fringed sagewort (*Artemisia frigida*) and annual forbs. All four waste amendments increased the production of annual forbs and fringed sagewort, but no amendment affected the production of perennial forbs. In 1994, drought throughout the growing season followed by late season rains affected plant response to the waste amendments applied in 1993. Total plant production in the control plots was higher in 1994 than in 1993, while total plant production with each of the waste treatments was comparable between the two years. Thus total 1994 plant production was increased only slightly (10%) in response to the 1993-applied composted manure and sewage sludge; increases were due to enhanced warm season grass production with the sewage sludge, and enhanced annual forb production with the composted manure. Fresh manure and phosphogypsum applied in 1993 suppressed plant production by 23-35% in 1994 due to lower production levels of warm season grasses and fringed sagewort. In the spring of 1994, 67 kg/ha fertilizer N (NH_4NO_3) was added to half of the plots treated with phosphogypsum, resulting in enhanced warm season grass production. We will continue to sample vegetation and soil for a minimum of three more years in order to assess changes in soil properties, subsurface water quality, forage production/quality, and species composition, as a result of a one-time waste application.

Aboveground Dry Matter Production, kg/ha

	1993					1994					
	Control	Fresh Manure	Composted Manure	Sewage Sludge	Phospho-gypsum	Control	Fresh Manure	Composted Manure	Sewage Sludge	Phospho-gypsum	P.gyp. +N
Annual Forbs	5.7	15.8	33.8	25.3	9.3	25.3	48.1	160.1	57.1	12.1	17.2
Perennial Forbs	34.3	35.2	31.9	35.4	38.6	17.9	60.7	22.4	19.5	24.7	20.8
Cool Season Grasses	86.6	29.7	90.0	57.9	49.6	44.7	44.9	64.5	40.2	76.5	26.0
Warm Season Grasses	695.2	613.3	866.9	1039.8	527.6	862.3	649.3	765.8	1078.7	562.3	1042.7
Fringed Sage	87.2	122.7	194.8	144.0	130.8	192.8	74.1	240.5	68.7	67.4	169.0
TOTAL	909.0	816.7	1217.4	1302.4	755.9	1142.9	877.0	1253.3	1264.1	742.9	1275.6

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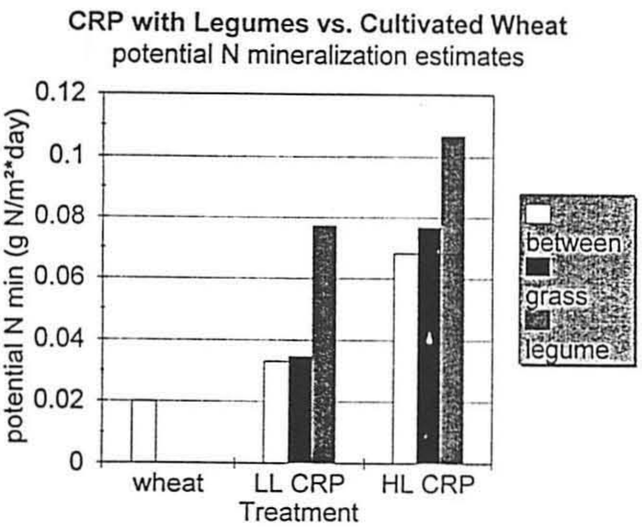
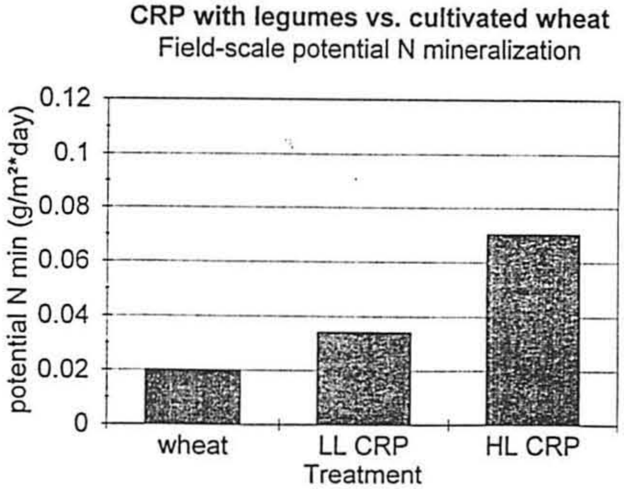
Robles, Marcos D. and I.C. Burke. The influence of the Conservation Reserve Program in the recovery of soil organic matter in previously cultivated soils.

One of the aims of the Conservation Reserve Program (CRP) is the conservation of the plants, soils and animals on land that had been previously tilled. However, the recovery of soil organic matter, the pool that provides nutrients for plant production, has not widely been investigated on CRP land. We conducted field and laboratory studies on a farm with CRP land in southeastern Wyoming to test the hypothesis that active indices of soil organic matter such as N and C mineralization are greater on CRP land compared to cultivated land, but that there is no difference in passive indices such as total soil organic matter. We also tested the hypothesis that when the legume species, *Medicago sativa* L. (alfalfa) and *Melilotus officinalis* L. (sweet clover), were seeded with the grass species, *Agropyron intermedium* ([Host] Beauv.) and *Bromus inermis* (Leyss.) (smooth brome), recovery of active pools would be accelerated when compared to heavy grass seedings. We have completed analyses of the active indices, N and C mineralization. These indices were fastest in soils underneath legumes as compared to grasses and bare soil. At the field level, CRP land seed with 80% legumes and 20% grasses contained soils with N and C mineralization rates about 2 times faster than CRP seeded with 20% legumes and 80% grasses and 3 times faster than rates on cultivated wheat soils. Because N mineralization rates are one measure of N availability to plants, these results suggest that CRP fields planted with a heavy mix of legumes are accumulating available nitrogen faster than CRP fields planted with a heavy mix of grasses.





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Smith, Susan M. and H. William Hunt. Change in atmospheric CO2 levels and the relationship between decomposition and chemical quality of shoots of Blue Grama and Western Wheatgrass.

The chemical quality of substrate affects the rate of litter decomposition. Increased atmospheric CO2 and related temperature and precipitation changes influence the chemical quality of the substrate by changing the plant growth rates and chemical composition. This was determined by a study conducted at the Central Plains Experimental Range from 1989 to 1993. The study was done on Pascopyrum smithii and Bouteloua gracilis grown under varying regimes of CO2, precipitation, and temperature. Decomposition experiments were carried out on litter from all treatments. The soils used in the experiment were from the original sites, and each litter was decomposed on its own soil and on the alternate soil. Each litter was decomposed on both intact soil cores and sieved soil cores. Decomposition was estimated gravimetrically and through CO2 respiration. The plants grown under higher CO2 grew larger, but with a decrease in nitrogen concentration. Litter decomposed on intact soil cores had higher weight loss. There was no effect of soil type on litter decomposition.

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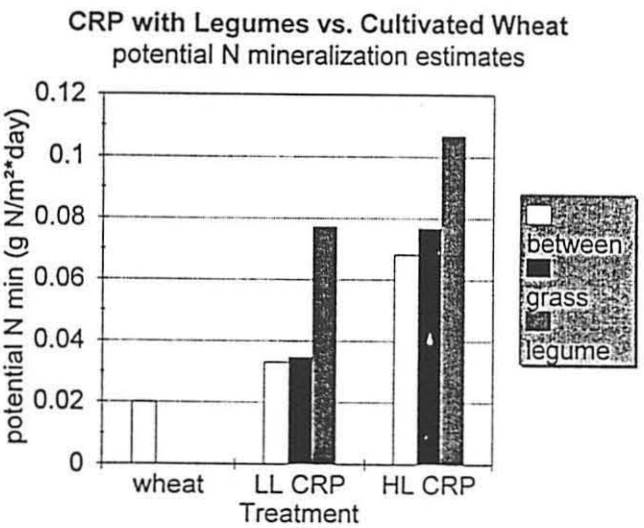

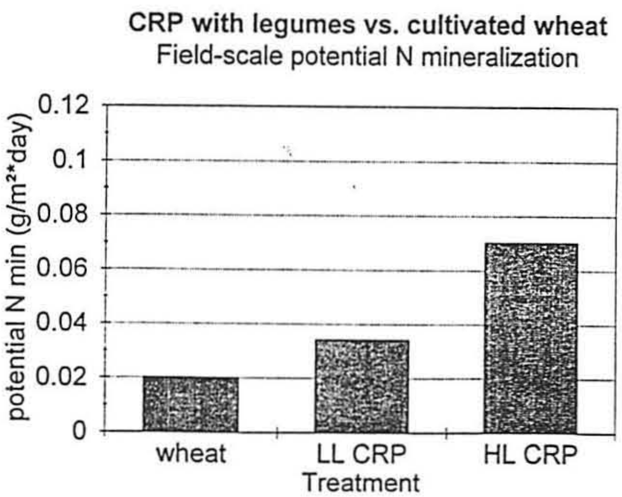

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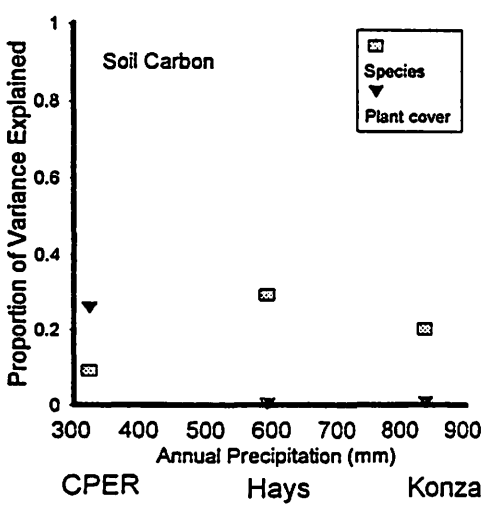
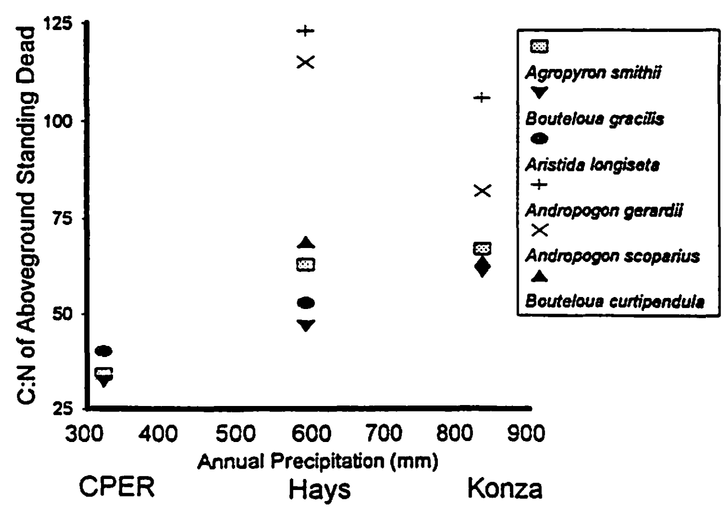
Vinton, Mary Ann, and Ingrid C. Burke. Plant effects on soil nutrient dynamics along a precipitation gradient in Great Plains grasslands

The central grassland region of the U.S. encompasses major gradients in temperature and precipitation that determine the distribution of plant lifeforms, which in turn may influence key ecosystem processes such as nutrient cycling and soil organic matter dynamics. One such gradient is the 3x increase in precipitation from the eastern Colorado shortgrass-steppe, in the rain shadow of the Rocky Mountains, to the tallgrass prairie in eastern Kansas. We investigated the relative roles of plant species and plant cover in influencing soil C and N cycling in three sites along this gradient.

Plant cover (i.e. the presence or absence of an individual plant) was relatively more important than plant species in explaining variability in soil properties at the dry site, the Central Plains Experimental Range in northeastern Colorado. However, plant species explained relatively more of the variability in soil properties than did plant cover at the two wetter sites, Hays and Konza, in central and eastern Kansas (see figure on the left). The wettest sites had more continuous plant cover, resulting in less plant cover-induced variation in soil C and N than did the dry site, which had distinct patches of bare ground and plant-induced "islands of soil fertility". Plant species at the wettest sites had higher and more variable levels of tissue C:N, than plant species at the dry site, due to both within species changes and changes in species composition (see figure on the right). Aboveground tissue C:N was better correlated with net nitrogen mineralization rates at the wet sites than the dry site. Thus, tissue chemistry controls on decomposition and nutrient cycling may be the reason for the higher impact of plant species on soil C and N at the wet than the dry sites.

These results indicate that the relative importance of plant cover patterns and plant species to soil C and N cycling varies over this gradient of increasing precipitation, with plant cover being most important at the dry end and plant species being most important at the wet end. The feedbacks between water availability and species composition and physiology over this regional gradient appear to be important in determining these patterns in plant-soil relationships.





CONDENSED RESEARCH PROPOSAL
1995 CPER SYMPOSIUM

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Spider Diversity and Landscape Ecology on shortgrass prairie:

I intend to study spider species diversity and recruitment to experimental habitat patches in relation to natural landscape features. I suggest the ideal setting for the proposed investigations is at the Central Plains Experimental Range (CPER) Long Term Ecological Research (LTER) site. This area is representative of the shortgrass steppe of the central Great Plains. Historically the grasslands east of the Rocky Mountains have been the home of free ranging buffalo, antelope, elk and plains Indians. It is this historical perspective in conjunction with present day land usage practices that provide the interesting elements for this study. Spider diversity and community structure investigations, in response to land usage and habitat patch dynamics, may provide valuable insights into questions on landscape ecology and biodiversity.

I intend to sample spider diversities between two distinct vegetation zones. a relatively homogenous buffalo grass and blue gramma landscape and a more heterogeneous environment of red threeawn, western wheatgrass, inland saltgrass, prickly pear cactus, fourwing saltbush and woody buckwheat. Spiders can be effectively captured by pitfall trapping (ground level traps that spiders fall into), sweeping vegetation cover (placing a white sheet under shrub and sweeping vegetation with a broom) and by sifting through litter areas immediately under shrubs. Vegetation cover maps may be utilized from previously mapped low altitude aerial photographs, GIS overlays and point sampling techniques.

I intend to evaluate habitat selection and dispersal of spiders between habitats by manipulating vegetation patches at various size and distance matrixes from a distinct heterogeneous vegetation gradient. Securely placed tumble weeds singularly and in various clump sizes may be used as experimental habitat patches. I plan to determine if spiders are moving between patches by capturing and marking spiders. Spiders can be marked using water-based acrylic paints. By using a variety of colors and positions on the abdomen, individual identifying marks may be placed on the spiders. Spiders can be painted relatively easily by trapping them between a pair of Dixie cups in which the bottom cup's end is removed and covered with a fine mesh wire that allows for painting and drying.

The benefits spider studies can provide, to the conservation and protection of species diversity and ecosystem understanding, stem from the ease of collection and the abundance of individuals and species. Spider diversity and community responses to manipulated habitats by experimentation may provide valuable information on corridor, boundary and habitat dynamics.

POSTER PRESENTATION

1995 CPER Symposium Form

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Welker, J. M., Yonker, C. and Kelly, E. F. A conceptual framework for the CPER-LTER that links the biological, atmospheric and earth sciences.

The conceptual framework of the CPER has been undergoing reevaluation for the past 8-12 months. The LTER group has been devising means of sharing with the scientific community the scope of our research which spans the atmospheric, biological and earth sciences which often operate at very different time and space scales. However, as we have come to realize, these disciplines are closely linked in their interactions and its is at these boundaries that we see new and novel research developing. We will present a poster that highlights our recent efforts to summarize both diagrammatically and verbally a framework which we consider to be meritorious of consideration by the group as representing the CPER-LTER broadbased conceptual framework.