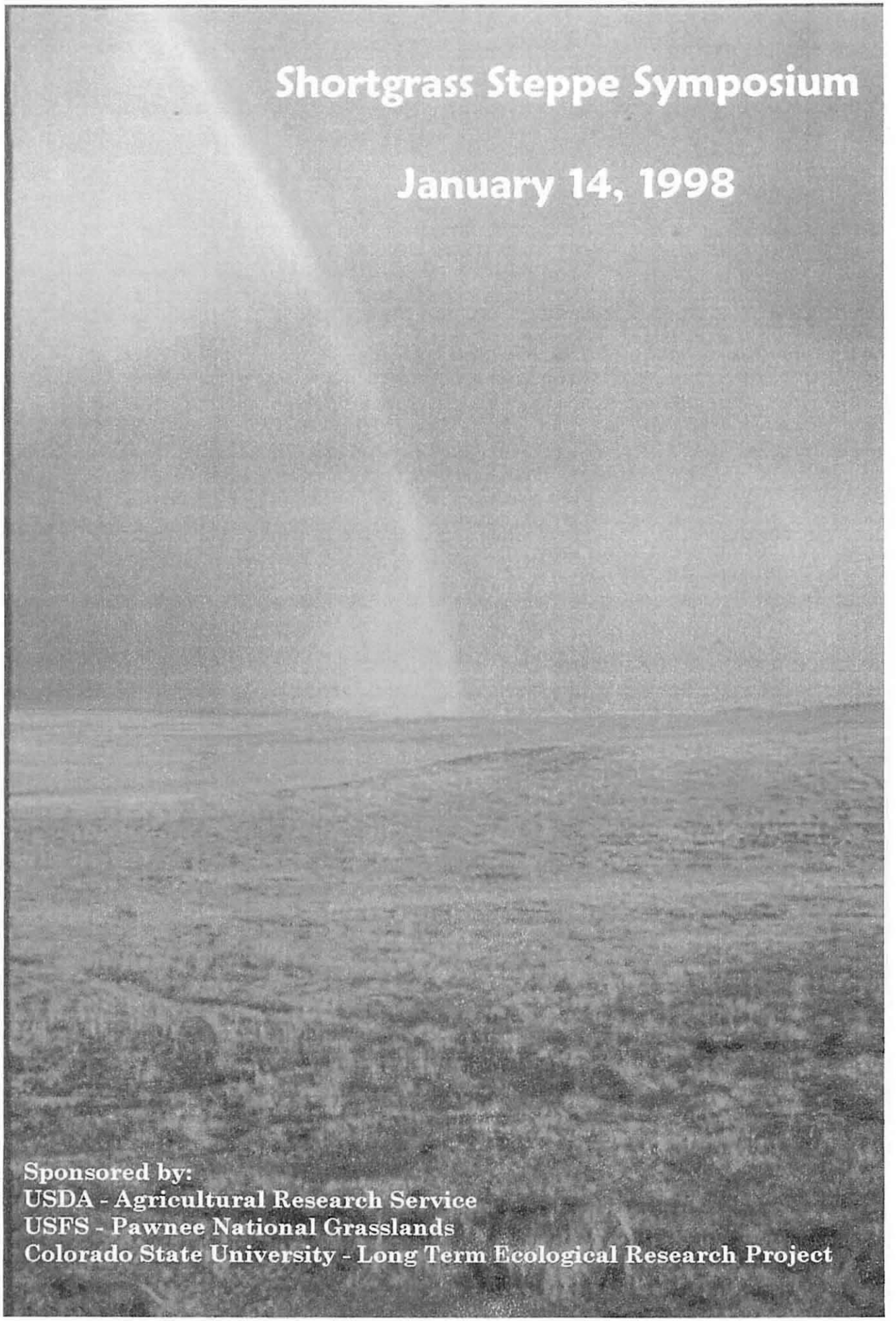
Shortgrass Steppe Symposium
January 14, 1998
Sponsored by:
USDA - Agricultural Research Service
USFS - Pawnee National Grasslands
Colorado State University - Long Term Ecological Research Project

# *1998 Shortgrass Steppe Symposium*

## *Agenda*

## *January 14, 1998*

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|---|---|
| **7:30** | **Arrival and Poster Mounting (coffee and rolls)** |
| **8:30** | **Opening address: "National Grassland management - The only thing constant is constant change"**<br>**Jeffery Losche, Pawnee National Grasslands** |
| **9:15** | **Poster Session #1** |
| **10:30** | **Break** |
| **11:00** | **Poster Discussions #1** |
| **12:00** | **Lunch and Shortgrass Steppe Trivia** |
| **1:00** | **Poster Session #2** |
| **2:30** | **Break** |
| **3:00** | **Poster Discussions #2** |
| **4:00** | **Closing Address: "Global change studies on the shortgrass steppe: Gas exchange and $CO_2$ enrichment studies"**<br>**Jack Morgan, Agricultural Research Service** |
| **4:30** | **Adjourn** |

# *1998 Shortgrass Steppe Symposium*
# *Participants*

| | |
|---|---|
| Dean Ackerman | ARS - Crops Research Laboratory |
| Rich Alward | CSU - Department of Biology |
| Menweylet Atsedu | CSU - Natural Resource Ecology Laboratory |
| Mark Ball | USFS - Pawnee National Grasslands |
| Jeb Barrett | CSU - Department of Forest Sciences |
| Andy Bean | CSU - Department of Rangeland Ecosystem Science |
| Scott Beard | CSU - Department of Forest Sciences |
| Joy Bergelson | University of Chicago |
| Brandon Bestelmeyer | CSU - Department of Biology |
| Bryce Bowman | Crow Valley Livestock Cooperative, Inc. |
| Kelly Bull | CSU - Natural Resource Ecology Laboratory |
| Ingrid Burke | CSU - Department of Forest Sciences |
| Dennis Child | CSU - Department of Rangeland Ecosystem Science |
| Stan Clapp | ARS - High Plains Grasslands Research Station |
| Martha Coleman | CSU - Department of Forest Sciences |
| Cheryl Danz | CSU - Department of Rangeland Ecosystem Science |
| Arvid DePorter | Crow Valley Livestock Cooperative, Inc. |
| Jim Detling | CSU - Department of Biology |
| Howard Epstein | CSU - Department of Forest Sciences |
| Jim Eussen | University of Northern Colorado - Biology Department |
| Darby Finley | University of Northern Colorado - Biology Department |

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| Jim Fitzgerald | University of Northern Colorado - Biology Department |
| Adam Fleener | CSU - Department of Rangeland Ecosystem Science |
| Gary Frasier | ARS - Crops Research Laboratory |
| Diana Freckman | CSU - Natural Resource Ecology Laboratory |
| Rick Gill | CSU - Department of Forest Sciences |
| Richard Hart | ARS - High Plains Grasslands Research Station |
| Judy Hendryx | CSU - Department of Rangeland Ecosystem Science |
| Irene Hesse | CSU - Department of Forest Sciences |
| Tamera Hochstrasser | CSU - Department of Rangeland Ecosystem Science |
| Bill Hunt | CSU - Natural Resource Ecology Laboratory |
| William Hunter | ARS - Crops Research Laboratory |
| Gordon Hutchinson | ARS - Soil/Plant Nutrient Research |
| Renee Jesser | University of Northern Colorado - Biology Department |
| Tom Juenger | University of Chicago |
| Jeanine Junell | CSU - Department of Biology |
| Dean Kanode | Crow Valley Livestock Cooperative, Inc. |
| Gene Kelly | CSU - Department of Agronomy |
| Robin Kelly | CSU - Natural Resource Ecology Laboratory |
| William Lauenroth | CSU - Department of Rangeland Ecosystem Science |
| Dan LeCain | ARS - Crops Research Laboratory |
| Mark Lindquist | CSU - Department of Rangeland Ecosystem Science |
| Glen Liston | CSU - Department of Atmospheric Science |
| Jeffery Losche | USFS - Pawnee National Grasslands |
| Petra Lowe | CSU - Department of Rangeland Ecosystem Science |
| Lixin Lu | CSU - Department of Atmospheric Science |

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| Chris Mahelona | ARS - High Plains Grasslands Research Station |
| Maggie Marston | USFS - Pawnee National Grasslands |
| Lowell McEwen | CSU - Department of Fisheries and Wildlife Biology |
| Nancy McIntyre | CSU - Department of Biology |
| Daniel Milchunas | CSU - Natural Resource Ecology Laboratory |
| John Moore | University of Northern Colorado - Biology Department |
| Jack Morgan | ARS - Crops Research Laboratory |
| Arvin Mosier | ARS - Soil/Plant Nutrient Research |
| Ken Murphy | CSU - Department of Forest Sciences |
| Denise Noble | CSU - Department of Forest Sciences |
| Dennis Ojima | CSU - Natural Resource Ecology Laboratory |
| Bill Parton | CSU - Natural Resource Ecology Laboratory |
| Mark Paschke | CSU - Department of Rangeland Ecosystem Science |
| Bob Peterson | USFS - Pawnee National Grasslands |
| Curt Peterson | University of Northern Colorado - Biology Department |
| Roger Pielke | CSU - Department of Atmospheric Science |
| Ed Redente | CSU - Department of Rangeland Ecosystem Science |
| Jean Reeder | ARS - Crops Research Laboratory |
| Larry Rittenhouse | CSU - Department of Rangeland Ecosystem Science |
| Jennifer Roach | CSU - Department of Biology |
| Ron Ryder | CSU - Department of Fishery and Wildlife Biology |
| Gerald Schuman | ARS - High Plains Grasslands Research Station |
| Jack Seifers | |
| Rose Shaillito | ARS - Crops Research Laboratory |
| Howard Skinner | ARS - Great Plains Systems Research Station |

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| David Smith | CSU - Department of Rangeland Ecosystem Science |
| Mary Smith | ARS - Soil/Plant Nutrient Research |
| Harvey Sprock | Natural Resources Conservation Service |
| Paul Stapp | University of Northern Colorado - Biology Department |
| Jerry Steenson | CSU - Department of Rangeland Ecosystem Science |
| Ernst Strenge | CSU - Department of Rangeland Ecosystem Science |
| Elizabeth Sulzman | CSU - Department of Agronomy |
| Peiter Tans | National Oceanic and Atmospheric Administration |
| Jeff Thomas | ARS - Central Plains Experimental Range |
| Larry Tisue | ARS - Soil/Plant Nutrient Research |
| Chris Wasser | CSU - Department of Rangeland Ecosystem Science |
| Barry Weaver | ARS - Crops Research Laboratory |
| John Wiens | CSU - Department of Biology |
| Caroline Yonker | CSU - Department of Agronomy |

# *1998 Shortgrass Steppe Symposium*
# *Poster Presentations*

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|---|---|
| Brandon Bestelmeyer | Ant communities of the Central Plains Experimental Range: new species and ongoing studies. |
| Kelly Bull | Comparison of rangeland sampling techniques in the Central Grasslands |
| Jim Detling | Effects of grazing history on regrowth, photosynthesis, and nitrogen dynamics of North American shortgrass steppe plants |
| Howard Epstein | Plant effects on spatial and temporal patterns of nitrogen cycling in shortgrass steppe |
| Darby Finley | Evaluation of the use of infrared triggered cameras for estimations of swift fox (*Vulpes velox*) populations and movement patterns of foxes |
| Gary Frasier | Erosional soil loss and its effects on rangeland health and productivity |
| Richard Hart | *Atriplex canescens* impact on understory vegetation under different seasons of grazing |
| Bill Hunt | Simulating growth and root-shoot partitioning in prairie grasses under elevated atmospheric $CO_2$ and water stress |
| William Hunter | Removing nitrate from groundwater using innocuous oils |

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| Gordon Hutchinson | Trace gas exchange in grazed vs. ungrazed shortgrass steppe |
| Tom Juenger | Genotype x environment interaction and the spatial scale of selective heterogeneity in *Ipomopsis laxiflora.* |
| Jeanine Junell | Differences in community structure of short-horned grasshoppers and tenebrionid beetles on and off black-tailed prairie dog towns. |
| Robin Kelly | Intra- and Interannual Variability of Ecosystem Processes in Shortgrass Steppe: new model, verification, and simulation. |
| Dan LeCain | $CO_2$ exchange rate of grazed and ungrazed pastures on the shortgrass steppe of Eastern Colorado |
| Lixin Lu | Simulating two-way interactions between atmosphere and ecosystem over the Great Plains |
| Nancy McIntyre | An empirical determination of the effects of landscape structure and the scale of patchiness on animal movements. |
| Arvin Mosier | N addition effects on trace gas fluxes in the Colorado shortgrass steppe. |
| Mark Paschke | Soil N availability and shortgrass steppe recovery on abandoned croplands |
| Jean Reeder | Shortgrass steppe soil carbon and nitrogen responses to grazing |

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|---|---|
| Jennifer Roach | Genetic structure of black-tailed prairie dog (*Cynomys ludovicianus*) populations in shortgrass steppe |
| Howard Skinner | Nitrogen circulation and dry matter partitioning during blue grama spring growth |
| David Smith | Survey of small mammals and their relationships with the black-tailed prairie dog (*Cynomys ludovicianus*) on the Pawnee National Grasslands |
| Paul Stapp | Ecological effects of black-tailed prairie dogs on fauna of shortgrass steppe |
| Elizabeth Sulzman | Isotope geochemistry of soil $CO_2$ along an elevational gradient in Colorado: Methods, development, and preliminary results |
| Jeff Thomas | A historical perspective of the Central Plains Experimental Range |

# Poster/Discussion Sessions

## *Discussion Moderator and time: Dick Hart - Morning*

| *Name* | *Poster Title* |
|---|---|
| Kelly Bull | Comparison of rangeland sampling techniques in the Central Grasslands |
| Jim Detling | Effects of grazing history on regrowth, photosynthesis, and nitrogen dynamics of North American shortgrass steppe plants |
| Richard Hart | Atriplex canescens impact on understory vegetation under different seasons of grazing |
| Gordon Hutchinson | Trace gas exchange in grazed vs. ungrazed shortgrass steppe |
| Dan LeCain | CO2 exchange rate of grazed and ungrazed patures on the shortgrass steppe of Eastern Colorado |
| Jean Reeder | Shortgrass steppe soil carbon and nitrogen responses to grazing |
| Jeff Thomas | A historical perspective of the CPER |

## *Discussion Moderator and time: Gene Kelly - Morning*

| *Name* | *Poster Title* |
|---|---|
| Gary Frasier | Erosional soil loss and its effects on rangeland health and productivity |
| William Hunter | Removing nitrate from groundwater using innocuous oils |
| John Moore | Microbial community dynamics in soils of manipulated native and grazed Ecosystems |
| Mark Paschke | Soil N availability and shortgrass steppe recovery on abandoned croplands |
| Elizabeth Sulzman | Isotope Geochemistry of Soil CO2 Along an Elevational Gradient in Colorado: Methods, Development, and Preliminary Results |

## *Discussion Moderator and time: Indy Burke - Afternoon*

| *Name* | *Poster Title* |
|---|---|
| Howard Epstein | Plant effects on spatial and temporal patterns of nitrogen cycling in shortgrass steppe |
| Bill Hunt | Simulating growth and root-shoot partitioning in prairie grasses under elevated atmosphericCO2 and water stress |
| Tom Juenger | Genotype x environment interaction and the spatial scale of selective heterogeneity in Ipomopsis laxiflora. |
| Robin Kelly | Intra- and Interannual Variability of Ecosystem Processes in Shortgrass Steppe: new model, verification, and simulation. |
| Lixin Lu | Simulating two-way Interactions between Atmosphere and Ecosystem Over the Great Plains |
| Arvin Mosier | N addition effects on trace gas fluxes in the Colorado shortgrass steppe. |
| Howard Skinner | Nitrogen circulation and dry matter partitioning during blue grama spring growth |

## *Discussion Moderator and time: Mark Ball - Afternoon*

| *Name* | *Poster Title* |
|---|---|
| Brandon Bestelmeyer | Ant communities of the Central Plains Experimental Range: new species and ongoing studies. |
| Darby Finley | Evaluation of the use of infrared triggered cameras for estimations of swift fox (Vulpes velox) populations and movement patterns of foxes |
| Jeanine Junell | Differences in community structure of short-horned grasshoppers and tenebrionid beetles on and off black-tailed prairie dog towns. |
| Nancy McIntyre | An empirical determination of the effects of landscape structure and the scale of patchiness on animal movements. |
| Jennifer Roach | Genetic structure of black-tailed prairie dog (Cynomys ludovicianus) populations in shortgrass steppe |
| David Smith | Survey of small mammals and their relationships with the black-tailed prairie dog (Cynomys ludovicianus) on the Pawnee National Grasslands |
| Paul Stapp | Ecological effects of black-tailed prairie dogs on fauna of shortgrass steppe |

1. Presenting Authors: B. T. Bestelmeyer and J. A. Wiens
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Bestelmeyer, B. T. and J. A. Wiens. Colorado State University. Ant communities of the Central Plains Experimental Range: new species and ongoing studies.

Ants (Hymenoptera: Formicidae) are abundant, conspicuous, and functionally important components of semiarid ecosystems. Ants are used worldwide as focal taxa in studies of the effects of environmental change on patterns of biodiversity. We describe our ongoing studies of the effects of grazing-induced and natural variation in habitat structure on the composition, diversity and functioning of ant communities at the Central Plains Experimental Range. Results from this site will compared with those of two other Long-Term Ecological Research sites, the Sevilleta LTER and the Jornada LTER, which collectively represent a biogeographic gradient from the shortgrass steppe biome to the Chihuahuan desert biome. By assessing the relative contributions of within- and between-site variation in the characteristics of ant communities, we may examine the relationships between the processes operating at different spatial scales that determine ant community structure and functioning and mediate the response of ants to anthropogenic disturbances.

We present a preliminary, revised species list for the CPER and point out some ecological characteristics that are known for the various taxa.

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Bull, Kelly[2], Thomas J. Stohlgren[1,2], and Yuka Otsuki[2]. [1] Biological Resources Division, USGS, and [2]Natural Resource Ecology Laboratory, Colorado State University, Fort Collins, CO 80523-1499, USA. Comparison of rangeland sampling techniques in the Central Grasslands.

We compared four rangeland vegetation sampling techniques to see how well they captured local plant diversity: the commonly used Parker transects and Daubenmire transects (as modified by the USDA Forest Service), a new transect and quadrat (TAQ), and the Modified-Whittaker multi-scale vegetation plot. We superimposed the methods in shortgrass steppe (Colorado), mixed grass prairie (Wyoming), northern mixed prairie (South Dakota), and tallgrass prairie (Minnesota) with four replicate study sites at each location. The Parker, TAQ, and Daubenmire transects significantly underestimated the total species richness, the number of native species, and the number of species with <1 % cover in each prairie type. The transect techniques also consistently missed half the exotic species, including noxious weeds, in each prairie type. For all prairie types, the Modified-Whittaker plot captured an average of 42.9 (+ 2.4; 1 S.E.) plant species per plot compared to 15.9 (+ 1.3), 18.9 (+ 1.2), 22.8 (+ 1.6) plant species per plot using the Parker, TAQ, and Daubenmire transect methods, respectively. Even with four replicate transects, the transect methods usually captured (and thus monitored) <50% of the plant species in each prairie type.

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Detling, J.K., M. Atsedu, and J.T. Fahnestock. Colorado State University. Effects of grazing history on regrowth, photosynthesis, and nitrogen dynamics of North American shortgrass steppe plants.

Few field studies have documented physiological differences in plants with different long-term grazing histories, and even fewer have examined how individual plants from populations with different grazing histories respond to defoliation. In these studies, we examined how long-term (>50 years) grazing history and defoliation affected regrowth and nitrogen dynamics of blue grama (*Bouteloua gracilis*) and western wheatgrass (*Pascopyrum smithii*) at the CPER, and we measured photosynthetic rates and leaf water potential in these species growing in areas grazed or protected from grazing since 1939.

In *P. smithii*, biomass of individual tillers, their N concentration, and their total N-yield were all higher in long-term protected populations than in long-term moderately grazed populations. However, differences resulting from their long-term grazing histories were usually quite small relative to the differences resulting from monthly defoliation. Moreover, while long-term grazing slightly decreased tiller N concentration and N-yield, current season defoliation substantially increased both of these. By contrast, *B. gracilis* exhibited fewer and less consistent responses to both long-term grazing history and current season defoliation. Net photosynthesis and stomatal conductance were also different more often in *P. smithii* than in *B. gracilis*. Rates were typically higher in leaves of *P. smithii* plants from the heavily grazed sites. We had hypothesized that water relations of plants from grazed sites would be more favorable because they had less leaf area from which water could transpire. However, this hypothesis was not supported, as we were unable to detect significant differences in leaf xylem pressure potentials between grazed and ungrazed plants. Thus, the cause of higher net photosynthetic rates and stomatal conductance in grazed *P. smithii* plants is not clear.

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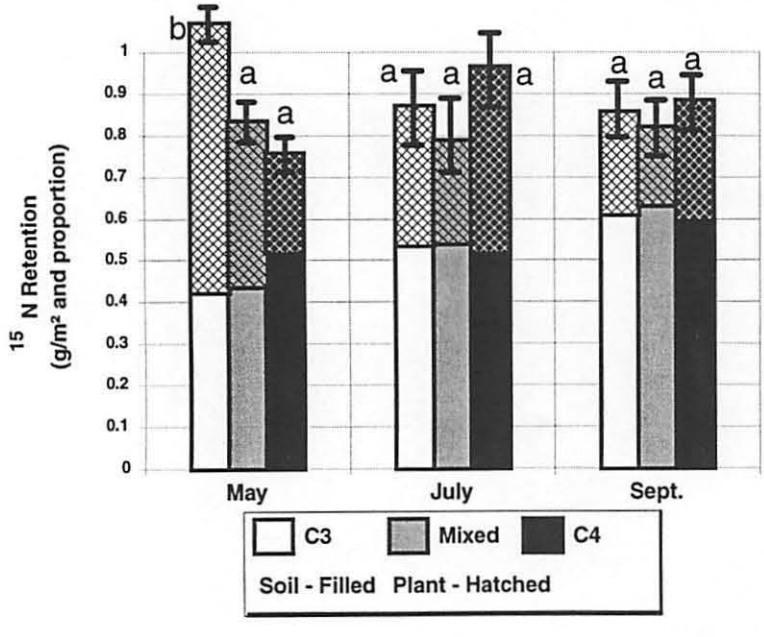
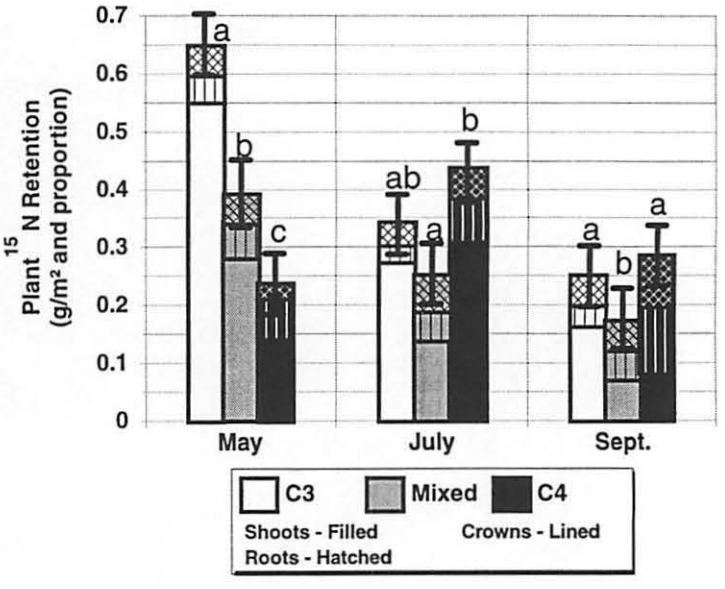
Epstein, H.E., I.C. Burke, and A.R. Mosier. Colorado State University and USDA Agricultural Research Service. Plant effects on spatial and temporal patterns of nitrogen cycling in shortgrass steppe.

Because of the water-limited nature and discontinuous plant cover of shortgrass steppe, spatial patterns in ecosystem properties are influenced more by the presence or absence of plants than by plant type. However, plant type may influence temporal patterns of nutrient cycling between plant and soil. Plants having the $C_3$ or $C_4$ photosynthetic pathway differ in phenology as well as other attributes that affect N cycling. We estimated net N mineralization rates and traced $^{15}N$ additions among plant and soil components during May, July and September of 1995 in native plots of $C_3$ plants, $C_4$ plants, or mixtures of $C_3$ and $C_4$.

Net N mineralization was significantly greater in $C_3$ plots than $C_4$ plots during both July and September. $C_3$ plots retained significantly more $^{15}N$ in May than mixed and $C_4$ plots; these differences in $^{15}N$ retention were due to greater $^{15}N$ uptake by $C_3$ plants than $C_4$ plants during May. There were no significant differences in total $^{15}N$ retention among plant communities for July and September. Soil $^{15}N$ was influenced more by presence or absence of plants than by type of plant; greater quantities of $^{15}N$ remained in soil interspaces between plants than in soil directly under plants for July and September.

Our results indicate that plant functional type ($C_3$ vs. $C_4$) can affect both the spatial and temporal patterns of nitrogen cycling in shortgrass steppe. Further research is necessary to determine how these intraseasonal differences translate to longer-term and coarser-scale effects of plants on N cycling, retention and storage.



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**Finley, D., J. Eussen, B. Roell, P. Stapp, J. P. Fitzgerald. University of Northern Colorado and T.D.I. Beck, Colorado Division of Wildlife. Evaluation of the use of infrared triggered cameras for estimation of swift fox (*Vulpes velox*) populations and movement patterns of foxes.**

In fall and winter of 1996-97 we used 35mm cameras triggered by infrared sensors to evaluate their usefulness in studies on swift foxes on the CPER and the Pawnee National Grasslands (PNG). Swift fox are primarily nocturnal in their foraging and use underground burrows as retreats during daylight hours making their study difficult. Infrared triggered cameras have been used on a number of species including black and grizzly bears and white tailed deer but not on small, nocturnal carnivores like the swift fox.

On the CPER we captured and dye marked 4 male and 4 female foxes and equipped them with painted dummy collars. In November-December we ran 3 camera sessions, averaging 4 nights per session, using 20 camera units on a 52 $km^2$ grid to see how many marked animals we photographed and to work out any technical difficulties with the system. We obtained 162 photographs of swift foxes including 66 (41%) of marked animals. All 8 marked animals were photographed at least once (range 1-20). Photographs of marked animals were taken at 11 of the 20 camera stations (55%). Significantly more photographs of the males were taken than of the females (55/66, 83%). Each male visited more than one camera with one male visiting 2, one 3, one 4, and one 5. By comparison each female only visited one camera site. On 7 occasions males visited more than one camera station per night with one male visiting 4 different cameras in one night. The major problem encountered was triggering of cameras by cattle otherwise the technique appeared suitable for an expanded test.

The objective of the PNG camera sessions was to estimate total swift fox population using photographs of radio-collared, dyed animals as "resights" in a modified Lincoln-Peterson estimator run on program NOREMARK. We ran 4 camera sessions using 31 camera units on a 160 $km^2$ grid on the PNG site in January and February averaging 5.5 days per session. Cattle were not present on the site. Ten female and 9 male swift foxes captured, dye-marked, and radio-collared in December were our known animals available for resighting. We obtained 469 photographs of foxes with 147 (31%) of them of marked, identified animals. All marked animals were photographed at least once. Nineteen of the 31 cameras (61%) were visited by marked foxes. Fourty-nine percent (72) of the photographs of marked animals were of males. Twenty-eight (90%) of cameras were visited by unmarked foxes. Using NOREMARK we estimated a mean fox population of 30.35 animals (range of 18-52 at 95% CI) on the study area based on the average of the 4 camera sessions. We believe this is a reasonable estimate of total winter population of foxes on shortgrass prairie in northern Colorado.

Other aspects of the usefulness of the camera systems are discussed including their value in helping understand fox movements and in detecting presence of other species.

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Frasier, G.W. (ARS), R.D. Child (CSU), W.C. Leininger(CSU), M.J. Trlica (CSU), G. Schuman (ARS) and J. Smith(U of Wyo). Erosional soil loss and its effects on rangeland health and productivity.

Many of the current rangeland assessment programs use plant components such as composition and productivity as indicators of rangeland condition and health. In reality, the plants are only indicators of the status of the soil-water-plant interaction. Loss of soil through wind and water erosion removes important nutrients and organic matter that supports plant cover and production. As soil and plant nutrients are lost, the plant component of the ecosystem is changed. However, little is presently known of the direct effects of soil loss on vegetation cover, composition and productivity and how these losses can be quantified with respect to rangeland health.

A study has been initiated to evaluate the impact of the level of soil loss on rangeland health and condition. Initial emphasis will be directed toward evaluating:

> "Are current soil loss tolerance standards of 5 tons/acre for rangelands affecting rangeland health? If not, what level of soil loss is critical?"

The study will evaluate the impact of 3 levels of soil removal (0, 5, 10 tons/acre) coupled with 3 levels of plant canopy cover removal (0, 30, 60% reduction) on hydrologic, vegetative, and soil parameters.

This study is a part of a regional study with other locations including Tucson, Arizona, and Las Cruces, New Mexico to develop quantifiable techniques for assessing rangeland health. Field data collection will be initiated in Spring of 1998.

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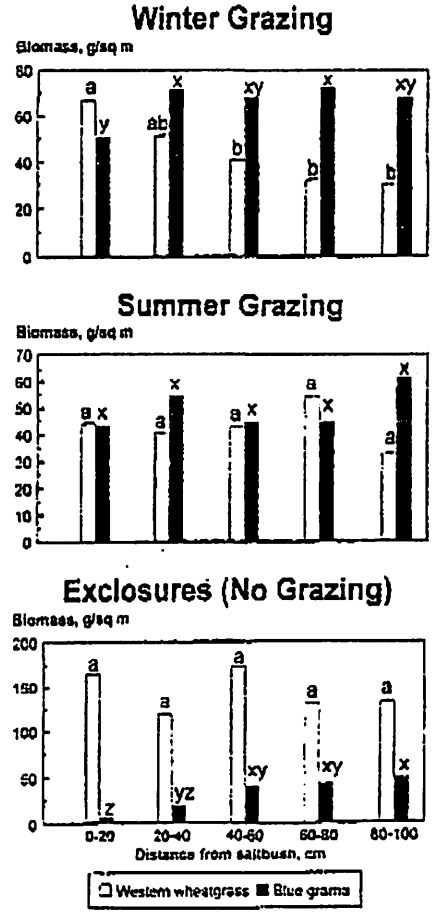
Hart, R. H.[1], A. F. Cibils[2], M. M. Ashby[1] and D. M. Swift[2]. [1]Agricultural Research Service, USDA, and [2]Natural Resources Ecology Laboratory, Colorado State University. *Atriplex canescens* impact on understory vegetation under different seasons of grazing.

Shrubs often provide refuges for plant species which, because of heavy grazing, have disappeared from the surrounding rangeland. On fourwing saltbush-blue grama-western wheatgrass (*Atriplex canescens-Bouteloua gracili-Pascopyrum smithii*) rangeland in northern Colorado, we located similar areas with different grazing histories on which to test the hypotheses that (1) western wheatgrass is more plentiful in the immediate vicinity of saltbush shrubs than in the intervals between shrubs, and (2) this difference may be related to season of grazing.

Two rangeland pastures had been grazed in the winter from 1985-86 through 1994-1995. Two adjacent pastures had been grazed in the summer from 1983 through 1994, but not in 1995. Two exclosures had not been grazed since they were established in about 1940 and 1970. In September 1995, a 50-m transect was located in each pasture and in each exclosure. On each transect, stem diameter, height, and crown diameter of the saltbush shrub nearest each meter mark was measured, as well as the distance to the shrub. At every fifth shrub, a 10 x 100 cm frame extending in a random direction from the shrub was placed with one end against a stem. This frame was sub-divided into five 10 x 20 cm sections. Vegetation in each section was clipped to ground level, dried at 60° C, separated by plant species, and weighed.

In the winter-grazed pastures, production of western wheatgrass decreased as distance from saltbush shrubs increased, while that of blue grama sometimes increased. Saltbush may have stimulated growth of western wheatgrass by increasing snow catch and soil moisture in early spring. No such effect was observed in summer-grazed pastures; the influence of grazing obscured any effects of distance from saltbush. In the exclosures, production of western wheatgrass was much greater than under grazing, and no effect of distance from saltbush could be detected, but production of blue grama was less than under grazing, and less near shrubs than at a greater distance. Average crown volume of saltbush was 0.25, 0.21 and 0.42 $m^3$ in summer-grazed, winter-grazed and exclosures, respectively; density was 4850, 3540 and 7500 plants $ha^{-1}$.



1. Presenting Author: H. W. Hunt
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Hunt, H. W., J. A. Morgan and J. J. Read. 1998. Simulating growth and root-shoot partitioning in prairie grasses under elevated atmospheric CO2 and water stress. Ann. Bot. (in press).

We constructed a model simulating growth, shoot-root partitioning, plant nitrogen (N) concentration and total non-structural carbohydrates in perennial grasses. Carbon (C) allocation was based on the concept of a functional balance between root and shoot growth, which responded to variable plant C and N supplies. Interactions between the plant and environment were made explicit by way of variables for soil water and soil inorganic N. The model was fitted to data on the growth of two species of perennial grass subjected to elevated atmospheric CO2 and water stress treatments.

The model exhibited complex feedbacks between plant and environment, and the indirect effects of the CO2 and water treatments on soil water and soil inorganic N supplies were important in interpreting observed plant responses. Growth was surprisingly insensitive to shoot-root partitioning in the model, apparently because of the limited soil N supply, which weakened the expected positive relationship between root growth and total N uptake. Alternative models for the regulation of allocation between shoots and roots were objectively compared by using optimization to find the least squares fit of each model to the data. Regulation by various combinations of C and N uptake rates, C and N substrate concentrations, and shoot and root biomass gave nearly equivalent fits to the data, apparently because these variables were correlated with each other. A partitioning function that maximized growth predicted too high a root to shoot ratio, suggesting that partitioning did not serve to maximize growth under the conditions of the experiment.

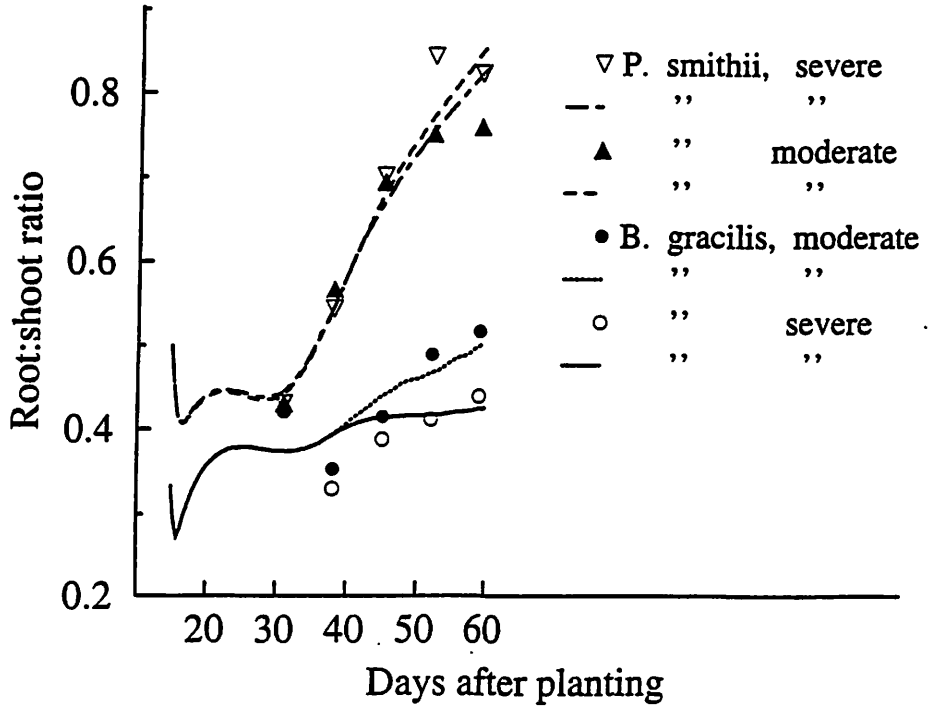


Figure 10. Effect of water treatment (moderate vs. severe water stress) on root to shoot ratio. Lines are model output and points are data from the experiment of Morgan et al. (1997). Both model and data are averages of the two levels of the CO2 treatment.

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Hunter, W.J. USDA-ARS. Removing nitrate from groundwater using innocuous oils.

Nitrate contamination of surface and subsurface waters is the most common water quality problem in the world. Nitrate in drinking water is of concern because it has been linked to methemoglobinemia in infants and may be associated with cancer in adults. Thus, it is a potential health threat in areas of high contamination. The maximum permissible level for drinking water in the USA has been set at 10 mg $NO_3$-N $L^{-1}$. Groundwater $NO_3$ contamination results from human activities that include agricultural operations, rural and urban septic discharge, mining operations, munitions storage facilities, etc. Contaminated groundwater is a problem in northeastern Colorado. The South Platte River Aquifer in northeastern Colorado has been contaminated by nitrate leaching from farmlands above the aquifer. Only about 30% of the water from this aquifer meets the drinking water standard and in some areas water from this aquifer exceeds the maximum permissible $NO_3$- N $L^{-1}$ level by a factor of four. Many smaller areas of contamination exist. On the Central Plains Experimental Range a relatively small nitrate plume derived from animal manures has contaminated the groundwater near the headquarters building.

Our studies suggest that innocuous oils can be used to protect aquifers from nitrate and to remove $NO_3$ from pumped groundwater. When oil was injected onto soil columns the oil become trapped in the soil matrix forming an immobile organic zone through which water could be pumped. Nitrate was removed as microbial denitrifiers, naturally present in the soil and water, utilized the oil as a carbon source. Both corn and soybean oil supported denitrification. In situ applications could involve the injection of oil into the ground to remove nitrate from water entering a well or the injection of oil to contain a $NO_3$ plume from a feedlot or spill. Simple above-ground reactors might be fashioned by mixing oil with sand and gravel to form a reactor for removing $NO_3$ from pumped groundwater.

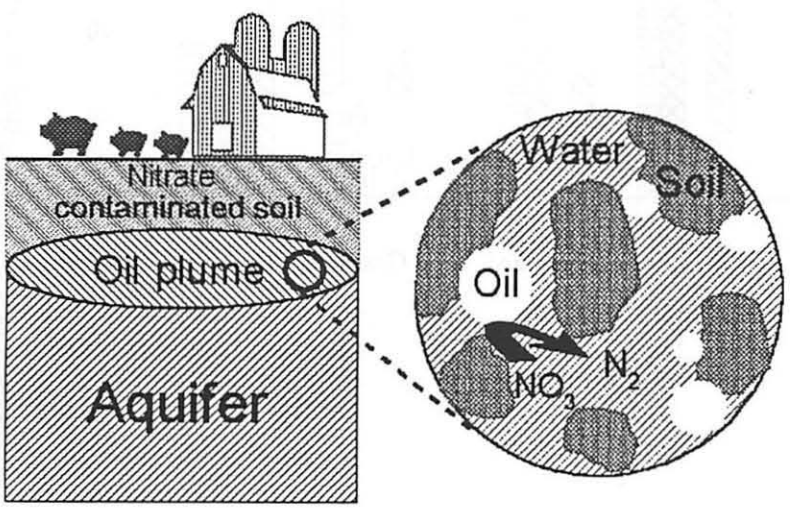


Figure showing how oil, injected into the ground to create a plume, might be used to protect an aquifer from soil contaminated with nitrate.

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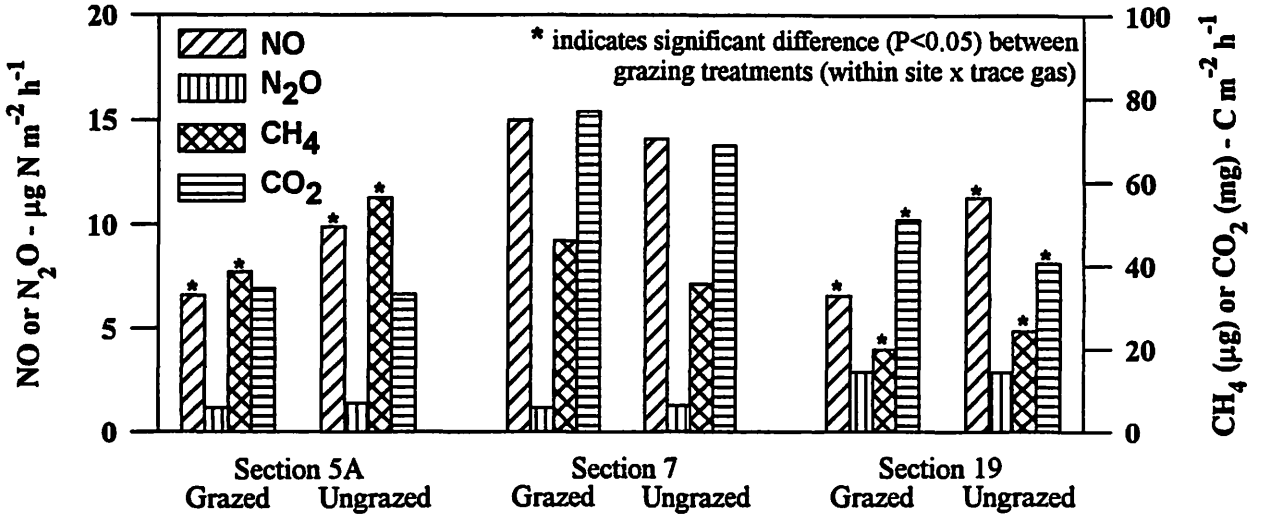
Hutchinson, G.L., A.R. Mosier, I.C. Burke, and W.J. Parton. USDA-ARS, Fort Collins, CO and Colorado State Univ. Trace gas exchange in grazed vs. ungrazed shortgrass steppe.

NO, $N_2O$, $CH_4$, and $CO_2$ are radiatively, chemically, and ecologically important trace atmospheric constituents. To evaluate intersite, interseasonal, interannual, and management-induced variability in their soil-atmosphere exchange, we monitored fluxes of the four gases at three paired grazed and ungrazed CPER sites at approximately weekly intervals from spring 1994 to early summer 1996; we also measured soil temperature and $NH_4^+$, $NO_3^-$ and $H_2O$ contents. Soil physical and chemical properties are given below.

- NO emission rates were significantly greater from the ungrazed than grazed treatment at sites 5 and 19 but not site 7, which had the greatest sand content and was thus less subject to impaired gas diffusion due to soil compaction by grazing animals. Compared to the other trace gases, total NO exchange was more influenced by emission pulses that followed warm-season precipitation on dry soil.
- $N_2O$ emission rates were not significantly different between grazing treatments at any site. Mean emission rates across treatments were greatest at site 19, probably because its higher total C, total N, and clay contents made the site more likely to support denitrification following heavy precipitation.
- $CH_4$ uptake rates were significantly greater in the ungrazed than grazed treatment at sites 5 and 19, but not site 7 which had the greatest sand content and thus may have been less subject to impaired gas diffusion due to soil compaction by grazing animals. Mean emission rates across treatments were substantially greater at sites 5 and 7 than site 19, which had the most clay and thus slower gas diffusion rates. Compared to the other trace gases, $CH_4$ uptake exhibited least interseasonal variability.
- $CO_2$ exchange rates were not significantly different between grazing treatments at sites 5 and 7, but were significantly greater in the grazed treatment at site 19. Interestingly, mean soil respiration across treatments was greatest at site 7, which had the greatest sand content and least total C and N.

We concluded that (1) grazing had relatively little influence on soil-atmosphere exchange of the four measured gases, (2) mean NO-N emission (over all sites and treatments) was more than six times greater than $N_2O$-N and may represent a key regulator of long-term grassland productivity, and (3) soil texture is a critically important trace gas exchange controller, primarily through its regulation of gas diffusion rates.

**Mean Trace Gas Exchange For Each Site x Treatment Combination**




| | Section 5A | | Section 7 | | Section 19 | |
|---|---|---|---|---|---|---|
| | Grazed | Ungrazed | Grazed | Ungrazed | Grazed | Ungrazed |
| sand (%) | 42 | 39 | 69 | 68 | 21 | 35 |
| silt (%) | 44 | 47 | 21 | 16 | 40 | 40 |
| clay (%) | 14 | 14 | 10 | 16 | 39 | 25 |
| bulk density | 1.15 | | 1.41 | | 0.92 | |
| total C (%) | 2.7 | | 1.3 | | 3.1 | |
| total N (%) | 0.26 | | 0.13 | | 0.28 | |
| pH | 7.3 | | 7.1 | | 7.3 | |

Soil Properties

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Thomas E. Juenger and Dr. Joy Bergelson. University of Chicago, Department of Ecology and Evolution. Genotype x environment interaction for fitness and the spatial scale of selective heterogeneity in a natural population on *Ipomopsis laxiflora.*

Rarely does a plant population adapt and evolve in a homogeneous environment. More generally, individuals within a population experience different levels of environmental variation on both coarse and fine spatial and temporal scales. Plants usually exhibit phenotypic plasticity in response to environmental variation, and more importantly, different genotypes within a population may differ in the extent of their plastic response. Genetic variation in phenotypic plasticity can be viewed as genotype x environment. The degree of genotype x environment interaction can have important evolutionary implications because it characterizes the potential of plant populations to respond to natural selection, will determine whether generalist versus specialist traits evolve, and may be a strong force maintaining genetic variation in nature.

The evolutionary importance of environmental heterogeneity will depend primarily on whether there are reversals in ranks among genotypes across the environment (G x E) and the scale of this variation in relation to dispersal. For example, if the environment were uniform on the scales at which progeny disperse, phenotypic plasticity would be unnecessary and genetic diversity would not be maintained by heterogeneous selection. Alternatively, if the environment is unpredictable on the scale which progeny disperse, phenotypic plasticity and polymorphism would be maintained. Although G x E is commonly invoked as a primary mechanism maintaining diversity, to date few studies have documented either the occurrence of genotypic rank changes across natural environmental gradients or the spatial scale of these changes in relation to dispersal.

We investigated the spatial scale of G x E for fitness in a population of a native forb, *Ipomopsis laxiflora.* We utilized a split-brood quantitative genetics experiment testing for G x E across a nested series of planting blocks spanning 90 square meters of prairie. Preliminary analyses indicate significant G x E for relative fitness across the largest spatial scale (45m). Future investigations will evaluate the scale of selective heterogeneity in relation to dispersal in *Ipomopsis laxiflora*, and what environmental factors may underlie the observed genotype x environment interaction.

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Junell, J. R., B. Van Horne. Colorado State University. Differences in community structure of short-horned grasshoppers and tenebrionid beetles on and off black-tailed prairie dog towns.

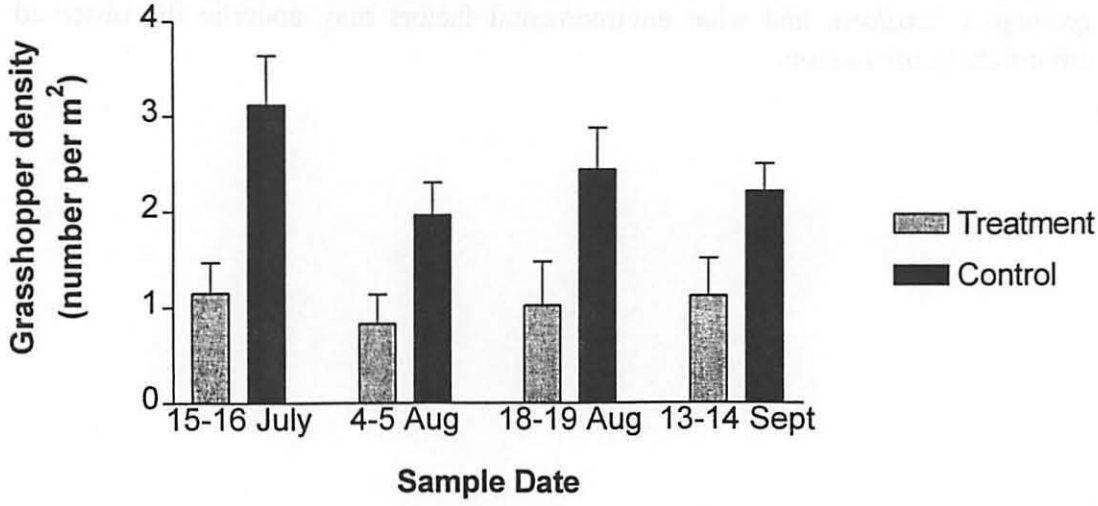
Prairie dogs (*Cynomys ludovicianus*) influence their surroundings in many ways. These herbivorous mammals change local plant community structure by cropping vegetation, and they modify the soil structure by burrowing and building mounds. These changes in vegetation and edaphic factors may influence insects such as beetles and grasshoppers that live in prairie dog towns. For my Master's research, I am asking the following question: Do short-horned grasshopper (Orthoptera: Acrididae) and darkling beetle (Coleoptera: Tenebrionidae) communities differ in the presence of prairie dogs? Looking at these groups will be a step toward determining the importance (including possible keystone species status) of prairie dogs in the shortgrass steppe.

Five prairie dog towns and five control sites were chosen on the western half of the Pawnee National Grassland in the spring of 1997. All five towns have been active since 1992, and all but one (Site 51) are on land that has no history of plowing. A control was selected for each town in areas with similar soil types and topography. These towns and controls are part of the Shortgrass Steppe Long-Term Ecological Research project looking at the effects of prairie dogs in the shortgrass steppe.

Short-horned grasshopper populations were sampled four times over the summer. Each sampling effort consisted of flushing grasshoppers from hoops to assess abundance and sweep netting to get an idea of species composition. Preliminary results indicate that there are fewer grasshoppers on prairie-dog towns than on the surrounding prairie. Prairie dogs seem to alter prairie habitats in a way that may be unfavorable for grasshoppers. Results for analyses of species composition are still being analyzed.

Tenebrionid beetles were sampled by pitfall traps once every 3 weeks from July through mid-September 1997. These data are still being analyzed.

I will conduct a second field season in the summer of 1998, repeating the sampling procedures described above. In addition, I am working on designing experiments that will examine the processes underlying changes in species composition and abundance of grasshopper and beetle communities.



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R. H. Kelly, W. J. Parton, M. D. Hartman, L. K. Stretch, D. S. Ojima, and D. S. Schimel. Intra- and Interannual Variability of Ecosystem Processes in Shortgrass Steppe: new model, verification, and simulation.

We introduced and tested a daily time step ecosystem model (DAYCENT) against field data at a daily, biweekly, monthly, and annual time step. The model effectively represented variability of ecosystem processes at each of these time scales. Evolution of $CO_2$ and $N_2O$, NPP, and net N mineralization were more responsive to variation in precipitation than temperature, while a combined temperature-moisture decomposition factor (DEFAC) was a better predictor than either component alone. Having established the efficacy of CENTURY at representing ecosystem processes at multiple time scales, we used the model to explore interannual variability over the period 1949-1996 using actual daily climate data. Precipitation was more variable than temperature over this period, and our most variable responses were in $CO_2$ flux and NEP. Net ecosystem production averaged 6 $gC/m^{-2}$/year and varied by 100% over the simulation period. We found no reliable predictors of NEP when compared directly, but when we considered NEP to be lagged by one year, predictive power improved. It is clear from our study that NEP is highly variable and difficult to predict. The emerging availability of system-level C balance data from a network of flux towers will be not only and invaluable source of information for assessments of global carbon balance, but a rigorous test for ecosystem models.

1998 SGS SYMPOSIUM

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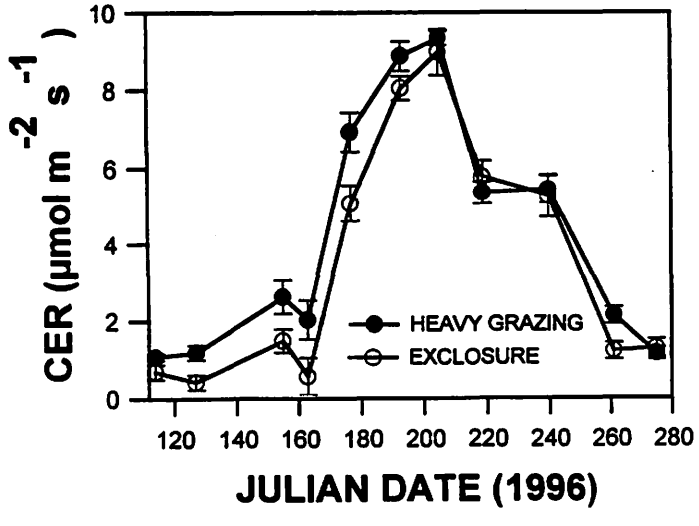
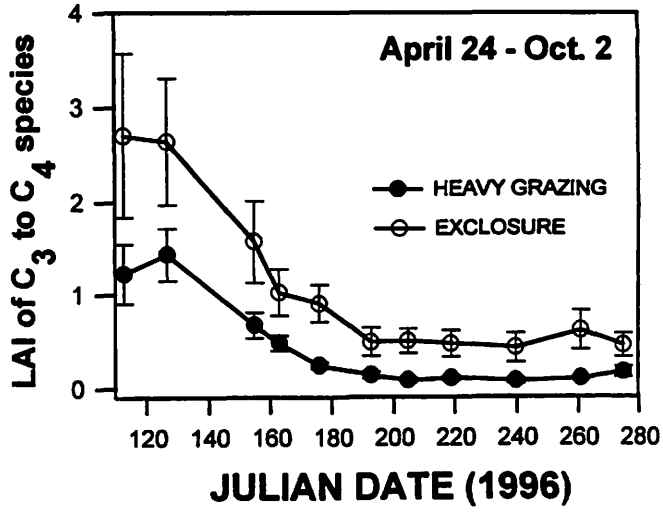
LeCain, D.R., J.A. Morgan, G.E. Schuman, R.H. Hart and J.D. Reeder. $CO_2$ Exchange Rate of Grazed and Ungrazed Pastures on the Shortgrass Steppe of Eastern Colorado.

In order to better understand the influence of cattle grazing on carbon cycling in the shortgrass steppe we measured $CO_2$ exchange rate (CER) of heavily grazed (.23 steers/ha) and lightly grazed (.12 steers/ha) pastures and their neighboring exclosures at the Central Plains Experimental Range, near Nunn CO. A closed system CER chamber which covered one $m^2$ of ground was used on five plots in each of the four pastures. Midday CER was measured every two or three weeks from April to October in 1995, 1996 and 1997 along with leaf area index (LAI), species composition, soil water content, soil temperature, soil respiration, air temperature and solar radiation. A site difference in soil water content precluded comparisons between grazing intensities. However, separate analyses of CER and related attributes between grazed and accompanying exclosed areas gave similar results for heavily and lightly grazed pastures

Seasonal differences between grazed and exclosed systems were not well related to LAI, but instead appeared to be related to differences in species composition caused by grazing. We consistently recorded a greater percentage of warm season ($C_4$) grasses in the grazed plots than in the exclosures (mostly *Bouteloua gracilis* and *Aristida longiseta*). A cool, wet spring in 1995 resulted in higher CER in the exclosures, which had a greater percentage of cool season ($C_3$) species (mostly *Stipa comata*, *Artemisia frigida* and *Carex* spp.). Warm, dry conditions during the spring of 1996 favored the photosynthetic physiology of warm season species, resulting in higher CER in grazed pastures. Grazing had little affect on CER in 1997. Differences in CER between grazed and exclosed plots diminished near mid-season in all three years and tended to remain very similar through autumn. Soil respiration, soil moisture and soil temperature were not significantly different between grazed and exclosed plots.



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Lixin Lu, Roger A. Pielke Sr., Glen E. Liston, Bill Parton, Dennis Ojima, and Melannie Hartman. Colorado State University. Simulating two-way Interactions between Atmosphere and Ecosystem Over the Great Plains

Abstract

Both observational and modeling studies have shown that the interactions between land surface and atmosphere are very important components of climate and ecosystem dynamics. To study the two-way interactions, a coupled RAMS (Regional Atmospheric Modeling System) and CENTURY (ecological model) modeling system has been developed. The off-line sensitivity analyses demonstrate that the two models are sensitive to the outputs of the other. The on-line coupling between RAMS and CENTURY is achieved through an internet stream socket and client/server mechanism. The coupled modeling system is used to simulate the interactions between atmosphere and ecosystem over the Great Plains for a full year. The initial simulation results show that the coupled model catches the synoptic signals as well as seasonal evolutions. It also has the ability to represent the short-term, medium-term and potentially the long-term (if we perform the multi-year simulation) feedbacks between the two systems. In addition, the coupled model has proved to be a valuable tool for physical process studies.

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McIntyre, Nancy. An empirical determination of the effects of landscape structure and the scale of patchiness on animal movements.

Effects of the scale of landscape patchiness on movement patterns of darkling beetles were examined in a 25-$m^2$ experimental model system, in a synthesis of theoretical and empirical landscape ecology. The ratio of habitat (grass) patches to non-habitat (sand) was held constant while the scale of patchiness (grass patch size) was varied. Beetle movement paths were surveyed and five metrics were used to quantify movement. Finely fragmented landscapes with small habitat patches elicited shorter and less linear paths than did coarsely fragmented landscapes with larger patches. Intermediate scales of patchiness elicited the strongest responses, suggesting that beetles perceive habitat patches of different sizes as having different functions (obstacles vs. resources). Our results indicate that the scale of spatial heterogeneity is as important as the presence of heterogeneity in affecting animal behavior, which has important implications for studies where the movement of organisms plays a key role. Such scale-dependent effects also illustrate how landscapes are not merely large stretches of land; rather, they are templates, regardless of size, upon which spatial patterning exists. Recognition of this distinction has implications for defining the focus of landscape ecology.

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N Addition Effects on Trace Gas Fluxes in the Colorado Shortgrass Steppe

To investigate the long-term effects of N addition to the Colorado shortgrass steppe (SGS) we made weekly, year-round measurements of nitrous oxide ($N_2O$) and methane ($CH_4$) from the spring of 1990 through June 1996. Fluxes of $NO_x$ ($NO + NO_2$), $N_2O$ and $CH_4$ reported here were measured from October 1995 through June 1996. These measurements illustrate that large N applications, from a single dose (45 g N $m^{-2}$), simulating cattle urine deposition, continued to stimulate $N_2O$ emissions from both sandy loam and clay loam soils 15 y after N application. In sandy loam soils last fertilized 15-y earlier, $NO_x$ emissions averaged 60% greater than from a comparable unfertilized site. The long term impact of these N additions on $CH_4$ uptake was soil dependent, with $CH_4$ uptake decreased by N addition only in the coarser textured soils. The immediate impact of small N additions (0.5 to 2 g N $m^{-2}$) on $N_2O$, $NO_x$ emissions and $CH_4$ uptake was observed in field studies made during the summer of 1996. There was little short-term effect of N addition on $CH_4$ uptake in either sandy loam or clay loam soils. Small N additions did not result in an immediate increase in $N_2O$ emissions from the sandy loam soil, but did significantly increase $N_2O$ flux from the clay loam soil. The reverse soil type- N addition interaction occurred for $NO_x$ emissions where N addition increased $NO_x$ emissions in the coarser textured soil 10 to 20 times those of $N_2O$.

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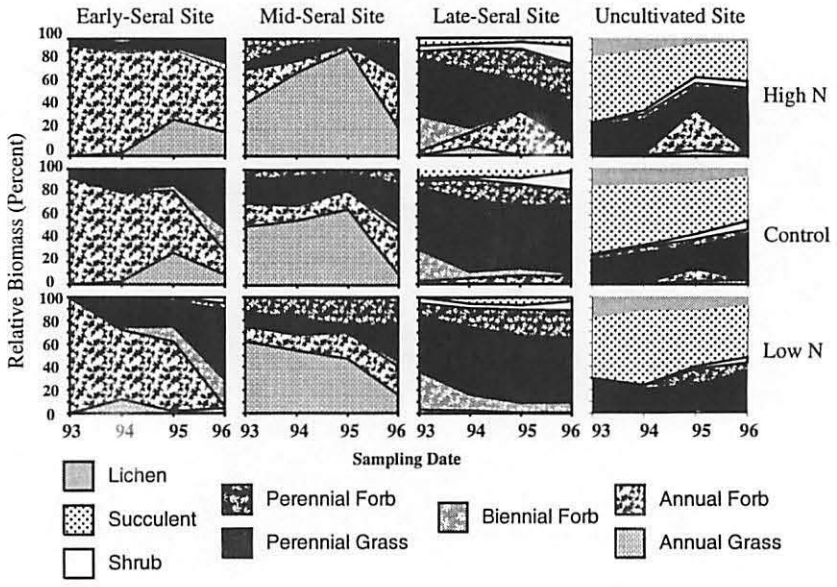
Paschke, M.W., E.F. Redente, D.A. Klein (CSU), and T. McLendon (University of Texas at El Paso). Soil N availability and shortgrass steppe recovery on abandoned croplands.

Soil nitrogen (N) availability influences the rate and course of secondary succession in numerous ecosystems. In this study, the relationship between N availability and above- and below-ground community structure and function was investigated along a chronosequence of old-fields in the shortgrass steppe of Colorado. N availability was experimentally manipulated for four years at four sites differing mainly in time since cultivation. Above-ground biomass of plants (by species) was determined twice annually and soil cores were used to estimate root biomass. Microscopic techniques were used to assess fungal and bacterial active biovolumes as a measure of soil microbial community responses. Decomposition rates were determined with mesh litter bags and N availability was monitored using ion exchange resin bags.

Results of our studies indicate that available N is an important factor controlling the rate and course of recovery of abandoned croplands in the shortgrass steppe. The addition of N slowed the rate of plant community succession at all of the previously cultivated sites in the study. Whereas, reducing N availability increased the rate of succession and recovery of the sites towards productive rangelands. Changes in N availability were coupled with distinct changes in soil microbial community composition and function during succession. The early-seral community had high rates of litter decomposition and a relatively large active microbial component. At the mid-seral stage, the active microbial community declined as did litter decomposition. This reduction in the abundance of active soil microbes and the associated process of decomposition during mid-succession occurred at a stage when there was a large build-up of plant litter and an exotic annual grass dominated the plant community. This mid-seral stage in the successional development of shortgrass steppe on abandoned croplands appears to be a critical "successional transition state" in the development of the plant-soil system.

Microbially-mediated N cycling is apparently an important controlling mechanism during early secondary succession in this shortgrass steppe system. By furthering our understanding of this mechanism it may be possible to manage rangeland vegetation through soil N availability manipulations.



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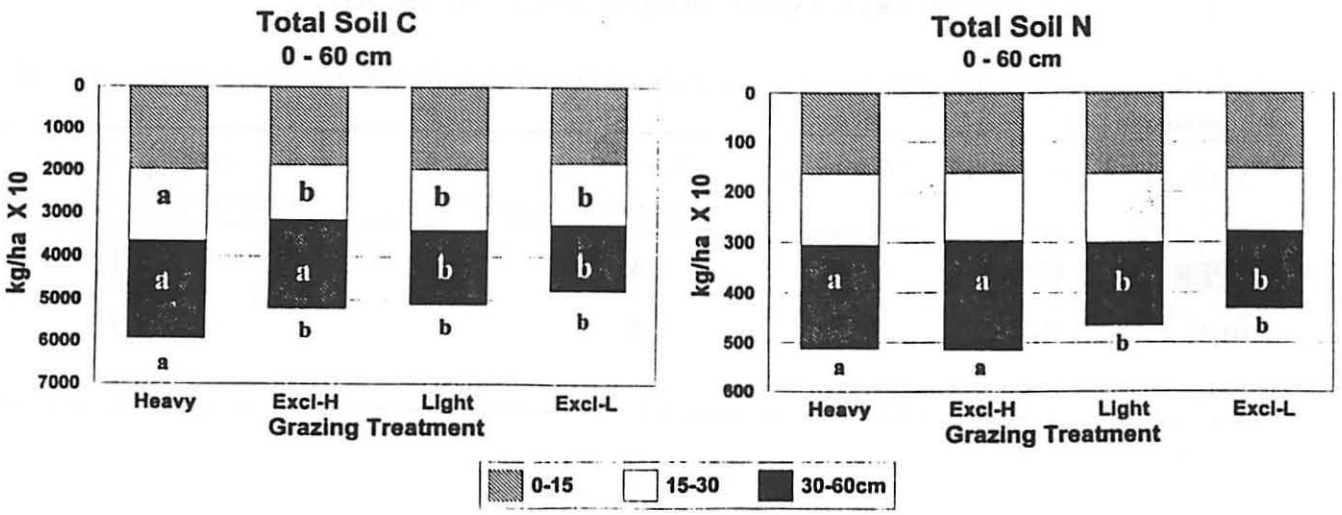
Reeder, J.D., G.E. Schuman, J.A. Morgan, D.R. LeCain, and R.H. Hart. USDA-ARS
Shortgrass steppe soil carbon and nitrogen responses to grazing.

Rangeland grazing management strategies are developed in an effort 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 within the soil-plant system. We evaluated the response of shortgrass steppe soil carbon (C) and nitrogen (N) to grazing by sampling the soils and vegetation of sites at the CPER with similar soil types and topographic positions but different grazing intensities. Grazing treatments included continuous season-long grazing each year for 55 years at either a heavy (70% utilization of annual production) or light (35% utilization) stocking rate. We also sampled exclosures, located immediately adjacent to each grazing treatment, that have not been grazed or burned for the past 55 years.

We sampled the vegetation of both grazing treatments and exclosures at peak standing crop (PSC), segregated into warm season grasses, cool season grasses, annual and perennial forbs, litter and standing dead. Root biomass was sampled within each clipped frame to a 30 cm depth with a 9.9cm diam. core. Soil cores (4.6 cm. diam.) were collected to 60 cm depth within each clipped frame and partitioned into 0-3.8, 3.8-7.6, 7.6-15, 15-30, 30-45, and 45-60 cm depth increments. Plant samples were analyzed for total C and N; soil samples were analyzed for both total and mineralizable C and N.

An evaluation of the results to date reveals no significant differences in N content of the soil profile to 60 cm between grazed and ungrazed treatments. However, the organic C content of the soil profile at 15-30 cm depth was significantly higher in the heavily grazed treatment compared to either exclosure or the lightly grazed treatment. Higher levels of N and C in the 30-60 cm depth increment of the heavily grazed pasture and its exclosure, compared to the lightly grazed pasture and exclosure, reflects a higher clay content at 30-60 cm in pasture 23W compared to pasture 23E. Long-term grazing at the heavy stocking rate resulted in a plant community dominated by warm season grasses (75% of abovegound biomass) and a root/shoot ratio of 13.1, whereas the plant community under light grazing exhibited a large forb component (45% of aboveground biomass) and a root/shoot ratio of 5.2. Thus the increase in C in the soil profile under heavy grazing was in part the result of grazing-induced increases in warm season grasses, which transfer more photosynthate belowground than forbs or cool season grasses.



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Roach, J. L., B. Van Horne, M. Antolin, and P. Stapp. Colorado State University. Genetic structure of black-tailed prairie dog (*Cynomys ludovicianus*) populations in shortgrass steppe.

The black-tailed prairie dog (*Cynomys ludovicianus*) is considered a keystone species because of its effects on the physical and biotic structure of grassland ecosystems. Prairie dog colonies in shortgrass steppe exist in spatially isolated subpopulations that are connected by dispersal, traits typical of metapopulations. The dynamics of these subpopulations are also determined by local colony extinction, which result from plague and agricultural control efforts. Difficulties in observing and quantifying dispersal behavior have complicated efforts to document the degree of connectedness between isolated colonies. However, patterns of genetic structure, and hence, relatedness, among populations can provide an estimate of the degree of linkage between subpopulations and be used to generate hypotheses about the types of behavioral processes responsible for these patterns. The objectives of this study are: 1) to establish levels of genetic heterogeneity within and among black-tailed prairie dog populations and 2) to evaluate proposed models of recolonization based on the degree of genetic differentiation among recolonized and established colonies.

We sampled 13 prairie-dog colonies in north-central Colorado from May through December 1997: six at the Central Plains Experimental Range (CPER) and seven at the Pawnee National Grasslands (PNG). Prairie dogs were live-trapped and marked with individual eartags. We recorded sex and body mass of all captured prairie dogs. A tissue sample (tail tip) was collected from each individual for genetic analysis. Genetic variability within and among populations of prairie dogs will be measured using microsatellite (simple sequence repetitive DNA) loci markers. Cluster analysis of data from the microsatellite markers will reveal patterns of relatedness among populations and be used to evaluate the role of dispersal in maintaining genetic diversity of the metapopulation.

Our goal is to collect tissue samples from at least 10-15 individuals in each colony. To date, we have adequate samples from 11 of 13 target populations. The live-trapping effort required to obtain these samples was intensive: on average, 3 person-days and 35 trap-days were required for each sample (Table 1). Furthermore, there was a significant difference in trappability of CPER and PNG populations (Table 1), which we attribute to differences in human shooting pressure between these study areas. Colony age and the timing of trapping may have also influenced trap success.

Results from this study may be used to describe and predict patterns of prairie dog metapopulation dynamics. Determining the effects of extinction and recolonization events on genetic diversity can provide predictions about the stability of metapopulations and provide possible guidelines for maintaining rare and endangered species in highly fragmented habitats.

Table 1. Summary of trapping effort and capture success of prairie-dog colonies, Pawnee National Grasslands, 1997.

| Study area | Person-days | Trap-days | Total captures | Total individuals | % Trap success (individ./trap-day x 100%) |
|---|---|---|---|---|---|
| CPER | 136 | 1488 | 174 | 76 | 5.1 |
| PNG | 201 | 2902 | 135 | 49 | 1.7 |
| Total | 337 | 4390 | 309 | 125 | 2.8 |

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Skinner, R.H. and J.D. Hanson. USDA-ARS, GPSR. Nitrogen circulation and dry matter partitioning during blue grama spring growth.

Models which mechanistically simulate plant growth and development must successfully partition carbon and nitrogen between roots and shoots, and between structural and non-structural biomass. To do so, the mechanisms which control substrate availability to growing tissues must be understood. Two contrasting theories on C and N partitioning between roots and shoots suggest that 1) priority is determined by proximity to the site of substrate uptake and assimilation, or 2) that due to circulating substrate pools, equal access is available to all growing tissues and priority is determined by demand.

This 2-yr study investigated N translocation to growing shoots, and structural and non-structural C and N accumulation in mature, field-grown blue grama (*Bouteloua gracilis* H.B.K. Lag. ex Steud.). Intact cores were extracted from an ungrazed site at CPER and transferred to Ft. Collins for in depth studies of root, crown and shoot growth, and N circulation. Growth was compared with cores sampled directly from CPER.

In both years, crown dry weight remained unchanged during a 3-wk period of active spring shoot growth. In 1995, root dry weight and N content decreased by 30 and 37% respectively during the same period, while both were unchanged in 1996. There was no net N uptake from the soil in either year. The N lost from roots in 1995 was sufficient to supply shoot N demand. Despite the lack of whole plant N accumulation, shoot structural dry weight and structural N accumulation were significantly correlated with soil $NO_3$ availability and shoot labile N concentration. Non-structural carbohydrate accumulation was a function of the combined effects of solar radiation and soil $NO_3$. Changes in shoot labile N could not be explained by the environmental parameters measured. Daily N delivery to growing shoots was more than 10 times greater than shoot N accumulation rate, suggesting that substantial root-shoot-root cycling occurred. Roots and shoots appeared to have equal access to available N so that proximity to the site of uptake did not control root:shoot partitioning.

| Evidence for root-shoot-root N cycling in mature, field-grown blue grama during spring vegetative growth. | |
|---|---|
| Xylem N concentration (mg $ml^{-1}$) | 0.084 |
| Transpiration rate (ml $d^{-1}$) | 39 |
| N delivery to shoot in xylem sap (mg $d^{-1}$) | 3.28 |
| N accumulation in shoot (mg $d^{-1}$) | 0.25 |
| Structural | 0.38 |
| Labile | -0.13 |
| N retention by shoot (% of delivered) | 7.6 |

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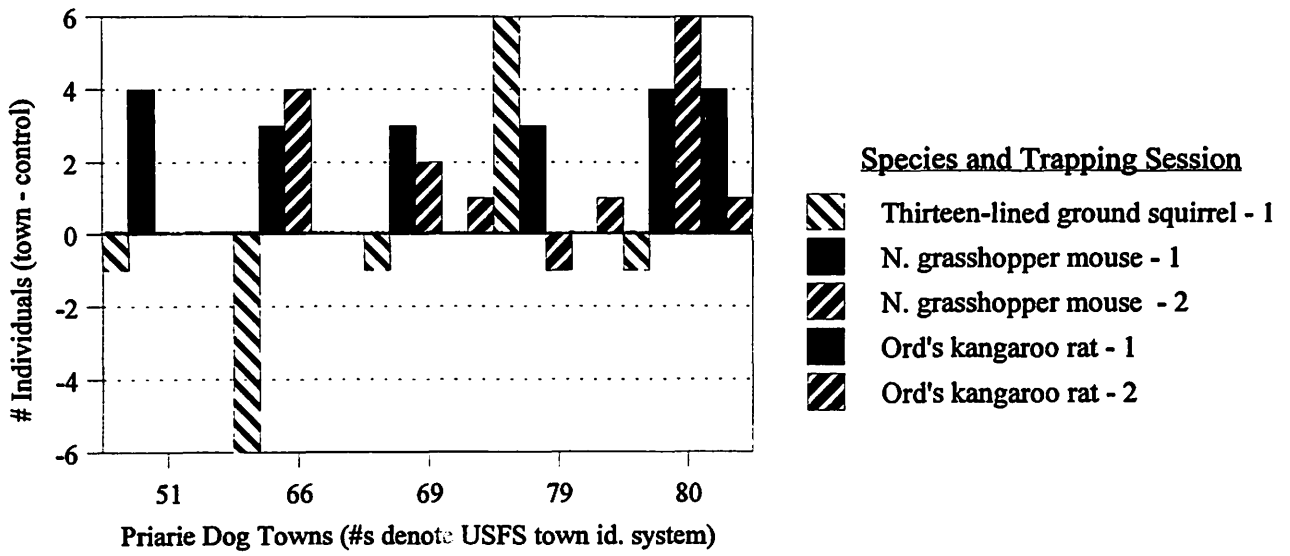
Smith, D. P., L. H. Clippard, P. Stapp, and M. Lindquist. Colorado State University.
Association of small mammals with the black-tailed prairie dog (*Cynomys ludovicianus*) on the Pawnee National Grasslands, Colorado.

Relatively few studies have examined the relationship between prairie dogs and small rodents, particularly in the shortgrass steppe ecosystem. Many small mammals are associated with the shortgrass steppe, including deer mice (*Peromyscus maniculatus*), grasshopper mice (*Onychomys leucogaster*), Ord's kangaroo rats (*Dipodomys ordii*), thirteen-lined ground squirrels (*Spermophilus tridecemlineatus*), and western harvest mice (*Reithrodontomys megalotis*). This study compares abundance and species richness of small mammals on prairie dog towns and similar shortgrass steppe sites in the Pawnee National Grasslands of north-central Colorado.

Small mammals were trapped in the Pawnee National Grasslands on five prairie dog towns and five controls. Control sites were paired with towns of similar soil types and vegetation. Traps were set for four consecutive nights during the new moon. We conducted two trapping sessions in 1997: June 30 - July 3 and September 30 - October 3. Trapping grids consisting of forty Sherman traps were placed in four rows of ten and established on each site. Total trapping area was 45 meters by 90 meters or 0.4 hectares. Traps were opened shortly before sunset and checked at dawn. In the first trapping session, traps were left open for several additional hours to permit the capture of thirteen-lined ground squirrels. Once captured, small mammals were identified, weighed and ear tagged. Age class, sex of animal and reproductive status were also recorded.

Our preliminary results for the first trapping session suggest that grasshopper mice were significantly more abundant in prairie dog towns. In addition, species richness was also significantly higher in prairie dog towns. However, in the second trapping session, no significant differences were found in abundance or richness between prairie dog towns and controls. The following graph shows the species captured in both trapping sessions except deer mice and silky pocket mice (*Perognathus flavus*), which were insignificant in abundance. More data is needed before any solid inference can be made on the impact of prairie dogs on small mammal populations in Pawnee National Grasslands.

Results from 1997 Small Mammal Trapping



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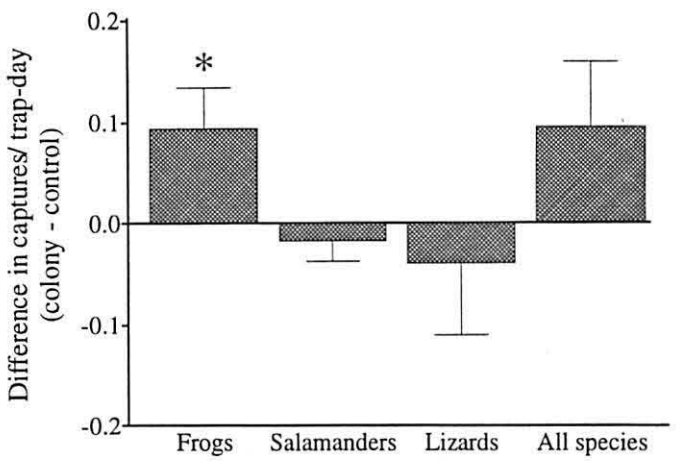
Stapp, P., M.D. Lindquist, and J.L. Roach. Colorado State University. Ecological effects of black-tailed prairie dogs on fauna of shortgrass steppe.

During the past decade, conservation biologists have argued that the protection of North American grasslands is linked to the survival of prairie dogs (genus *Cynomys*), which many consider to be keystone species because of their effects on primary productivity, soil and nutrient dynamics, and biotic diversity. However, our understanding of the ecological effects of prairie dogs on grassland ecosystems comes largely from studies conducted in mixed-grass prairies, despite the fact that nearly 40% of the range of the most widespread and economically important species, the black-tailed prairie dog (*C. ludovicianus*), is in shortgrass steppe. Differences between shortgrass steppe and taller, more productive grasslands in climate and tolerance of herbivory suggest that both plant and animal communities in shortgrass steppe may respond differently than those in other grasslands. This may be particularly true for consumer species: while some specialized species such as the black-footed ferret clearly depend on prairie dogs for survival, less is known of the effects on prairie dogs on other animals, and especially, the fauna of shortgrass steppe. Successful management and conservation of "the prairie dog ecosystem" throughout North America thus depends not only on our knowledge of the ecological effects of prairie dogs, but also on a better understanding of how these effects differ in different grasslands.

In Spring 1997, the Shortgrass Steppe Long-Term Ecological Research project began research to determine the ecological role of the black-tailed prairie dog in shortgrass steppe. Rectangular plots (1.2 ha) were established on five prairie-dog colonies on the Pawnee National Grasslands. These were paired with plots on nearby areas with similar vegetation, topography, soil type, and land-use history. Separate studies are examining the effects of prairie dogs on plant productivity and diversity, community structure of terrestrial arthropods (Junell and Van Horne poster), and population genetics of prairie dogs (Roach et al. poster). Our studies have focused on how the presence of prairie dogs affect populations and communities of other small vertebrates, including small mammals (Smith et al. poster), amphibians, and lizards (Fig. 1). We are also investigating possible mechanisms to explain these patterns, including habitat modification by prairie dogs via clipping of vegetation and the construction and maintenance of mounds, and the indirect effects of prairie dogs on arthropod prey of insectivorous/ omnivorous vertebrates.

Our poster will summarize the results from the first field season of sampling. We hope to expand our studies in 1998 to include other animals not currently sampled, including rabbits, birds, and snakes, and will present tentative plans for accomplishing these studies. Feedback on our ongoing studies and future plans is greatly appreciated.

Fig. 1. Although our early results suggest that most herpetofauna show no preference for prairie-dog colonies, frogs were significantly more abundant in colonies than in uncolonized areas during the wet summer of 1997. Data are from captures in pitfall traps on three colony plots and the associated controls.



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Sulzman, E. (Colorado State University) "Isotope Geochemistry of Soil CO2 Along an Elevational Gradient in Colorado: Methods Development and Preliminary Results"

The goal of the proposed work is to understand the differential effects of climate variability on photosynthesis and respiration on seasonal to interannual scales. The proposed work involves three phases. Phase I: collect data on the d13C and d18O of soil water, soil atmosphere, soil organic matter, plant material, and bulk air along a climatic (elevational) gradient in Colorado. These data will be used to establish the end members necessary to determine the relationships between component fluxes of photosynthesis, respiration, evaporation, and transpiration. Phase II: attempt to quantify the diurnal, daily, and seasonal changes to the net fluxes of evapotranspiration and net ecosystem exchange, and expand my study to Wisconsin, where I will include measurements off a 450 m transmitter tower in order to determine the signatures of fluxes integrated over a larger spatial scale. Phase III: integrate findings and determine if the data can be used to provide information to an ecosystem model (CASA or Century).

The application of new stable isotope techniques, atmospheric sampling, and biogeochemical models promise an evolution, if not a revolution, in quantifying the processes that regulate terrestrial ecosystem effects on the global carbon cycle. These techniques, in addition to more traditional approaches, will help us assess critical processes as well as seasonal and interannual variability in ecosystems. A better understanding of the relationship between carbon dioxide and water fluxes will assist in the evaluation and improvement of predictive models capable of evaluating ecosystem response to perturbations.

Specific questions to be addressed:

1. What are the precise isotopic signatures of the component fluxes that make up evapotranspiration and net ecosystem CO2 exchange?
2. How well can we integrate the isotopic variations in the surface measurements to represent a spatially-averaged component flux of CO2 or H2O?
3. What are the vertical gradients of isotopes in CO2 and H2O within the canopy, and how well can we discern contributions due to soil respiration, canopy recycling, and mixing with the atmosphere?
4. To what extent can we integrate canopy-scale estimates of component fluxes, based on the above, to larger-scale estimates (tall tower footprint, region, etc.)?

# 1998 SGS Symposium

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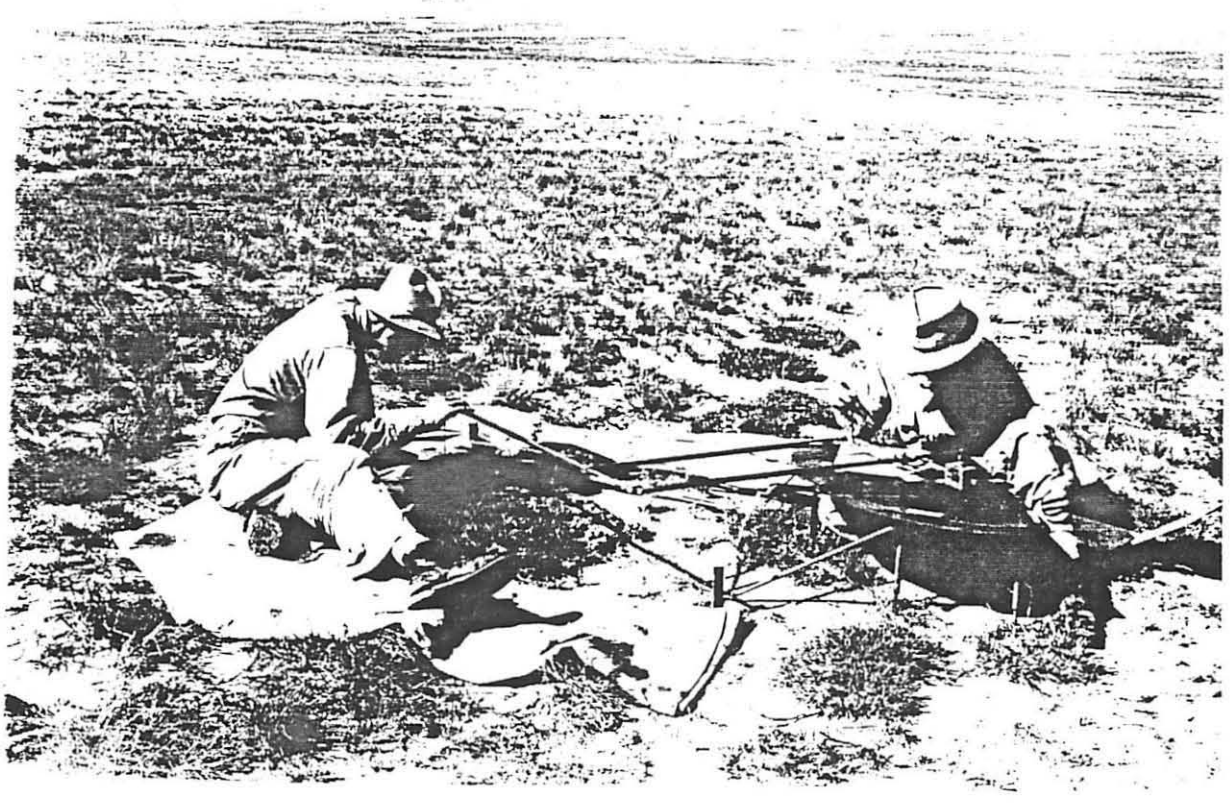
Thomas, Jeffry B. And Mary M. Ashby. (Non-technical poster)

**A Historical Perspective of the CPER**

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



**Stohlgren, T.J., Bull, K.A. and Otsuki Y. 1998. Comparison of Rangeland Vegetation Sampling Techniques in the Central Grasslands. Journal of Range Management (In Press).**

**Abstract**

Because maintaining native plant diversity, detecting exotic species, and monitoring rare species are becoming an important objectives in rangeland conservation, we compared four rangeland vegetation sampling techniques to see how well they captured local plant diversity. The methods tested included the commonly used Parker transects and Daubenmire transects (as modified by the USDA Forest Service), a new transect and quadrat (TAQ) design proposed by the USDA Agricultural Resource Service, and the Modified-Whittaker multi-scale vegetation plot. We superimposed the methods in shortgrass steppe (Central Plains Experimental Range, Pawnee National Grassland, Nunn, Colorado), mixed grass prairie (High Plains Experiment Station, Cheyenne, Wyoming), northern mixed prairie (Wind Cave National Park, Hot Springs, South Dakota), and tallgrass prairie (Pipestone National Monument, Pipestone, Minnesota) with four replicate study sites at each location. Analysis of variance tests showed significant methods effects and sites effects, but no significant method x site interactions for total species richness, the number of native species, the number of species with <1 % cover, and the time required for sampling. Thus, the methods behaved similarly in each prairie type under a wide variety of grazing regimes. The Parker, TAQ, and Daubenmire transects significantly underestimated the total species richness, the number of native species, and the number of species with <1 % cover in each prairie type. The transect techniques also consistently missed half the exotic species, including noxious weeds, in each prairie type. The Modified-Whittaker method, which includes an exhaustive search for plant species in a 20 x 50 m plot, served as the baseline for species richness comparisons. For all prairie types, the Modified-Whittaker plot captured an average of 42.9 (± 2.4; 1 S.E.) plant species per plot compared to 15.9 (± 1.3), 18.9 (± 1.2), 22.8 (± 1.6) plant species per plot using the Parker, TAQ, and Daubenmire transect methods, respectively. The four methods captured most of the dominant species at each site and, thus, produced similar results for total foliar cover and soil cover. The detection and measurement of exotic plant species was greatly enhanced by using ten 1 $m^2$ subplots in a multi-scale sampling design and searching a larger area (1,000 $m^2$) at each site. Even with four replicate transects, the transect methods usually captured (and thus monitor) <50% of the plant species in each prairie type. To evaluate the status and trends of common, rare, and exotic plant species at local, regional, and national scales, innovative, multi-scale methods must replace the commonly used transect methods of the past.

**Other Related Projects:**

**Stohlgren, T. J., Binkley, D., Chong, G.W., Kalkhan, M.A., Schell, L.D., Bull, K.A., Otsuki, Y., Newman, G., Bashkin, M. and Son, Y. 1998. Exotic Plant Species Invade Hot Spots of Native Plant Diversity. Ecology (In Press).**

**Abstract**

Some theories and experimental studies suggest that areas of low plant species richness may be invaded more easily than areas of high plant species richness. We gathered nested-scale vegetation data from 200 1-$m^2$ subplots (20 1000-$m^2$ plots) in the Colorado Rockies, and

180 1-$m^2$ subplots (18 1000-$m^2$ plots) in the Central Grasslands in Colorado, Wyoming, South Dakota, and Minnesota to test the generality of this paradigm. At the 1-$m^2$ scale, the paradigm was supported in four prairie types in the Central Grasslands, where exotic species richness declined with increasing plant species richness and cover ($n=160$, $R^2=0.18$, richness $t=-3.65$, $P<0.001$, cover $t=-2.36$, $P<0.019$). At the 1-$m^2$ scale, five forest and meadow vegetation types in the Colorado Rockies contradicted the paradigm; exotic species richness increased with native plant species richness and foliar cover ($n=200$, $R^2=0.21$, richness $t=4.72$, $P<0.001$, cover $t=2.35$, $P<0.020$). At the 1000-$m^2$ plot scale (among vegetation types), 83% of the variance in exotic species richness in the Central Grasslands was explained by soil total % N (n=16 plots, coefficient = 24.1, F=57.38, P<0.001) and the cover of native plant species (coefficient = -0.06, F=5.74, P<0.032). In the Colorado Rockies, 69% of the variance in exotic species richness in 1000-$m^2$ plots was explained by the number of native plant species (n=17 plots, coefficient = 0.147, F=31.88, P<0.001) and soil total % C (coefficient = 0.502, F=5.66, P<0.03). At landscape and biome scales, exotic species primarily invaded areas of high species richness in the for Central Grasslands sites ($r^2=0.85$, $P<0.078$) and in the five Colorado Rockies vegetation types ($r^2=0.81$, $P<0.038$). For the nine vegetation types in both biomes, exotic species cover was positively correlated mean foliar cover (r=0.50, P<0.171), mean soil %N (r=0.73, P<0.024), and the total number of exotic species (r=0.87, P<0.002). These patterns of invasibility depend on spatial scale, biome and vegetation type, spatial autocorrelation effects, availability of resources, and species-specific responses to grazing and other disturbances. We conclude that: (1) sites high in herbaceous foliar cover and soil fertility, and hot spots of plant diversity (and biodiversity) are invasible in many landscapes; and (2) this pattern may be more closely related to the degree resources are available in native plant communities, independent of species richness. Exotic plant invasions in rare habitats and distinctive plant communities pose a significant challenge to land managers and conservation biologists.

**Stohlgren, T. J., Bull, K.A., Otsuki, Y., Villa, C.and Lee, M. Riparian Zones as Havens for Exotic Plant Speciesin the Central Grasslands. 1998. Plant Ecology (In Press).**


## Abstract

In the Central Grasslands of the United States, we hypothesized that riparian zones high in soil fertility would contain more exotic plant species than upland areas of low soil fertility. Our alternate hypothesis was that riparian zones high in native plant species richness and cover would monopolize available resources and resist invasion by exotic species. We gathered nested-scale vegetation data from 40 1 $m^2$ subplots (nested in four 1000 $m^2$ plots) in both riparian and upland sites at four study areas in Colorado, Wyoming, and South Dakota (a total of 320 1$m^2$ subplots and 32 1000 $m^2$ plots). At the 1 $m^2$ scale, mean foliar cover of native species was significantly greater ($P<0.001$) in riparian zones (36.3 % $\pm$ 1.7%) compared to upland sites (28.7% $\pm$ 1.5%), but this small scale there were no consistent patterns of native and exotic species richness among the four management areas. Mean exotic species cover was slightly higher in upland sites compared to riparian sites (9.0% $\pm$ 3.8% versus 8.2% $\pm$ 3.0% cover). However, mean exotic species richness and cover were greater in the riparian zones than

upland sites in three of four management areas. At the 1000 $m^2$ scale, mean exotic species richness was also significantly greater ($P < 0.05$) in riparian zones ($7.8 \pm 1.0$ species) compared to upland sites ($4.8 \pm 1.0$ species) despite the heavy invasion of one upland site. For all 32 plots combined, 21% of the variance in exotic species richness was explained by positive relationships with soil % silt ($t = 1.7$, $P=0.09$) and total foliar cover ($t = 2.4$, $P=0.02$). Likewise, 26% of the variance in exotic species cover ($\log_{10}$ cover) was explained by positive relationships with soil % silt ($t = 2.3$, $P=0.03$) and total plant species richness ($t = 2.5$, $P=0.02$). At landscape scales (four 1000 $m^2$ plots per type combined), total foliar cover was significantly and positively correlated with exotic species richness ($r= 0.73$, $P<0.05$) and cover ($r=0.74$, $P<0.05$). Exotic species cover ($\log_{10}$ cover) was positively correlated with $\log_{10}$ % N in the soil ($r=0.61$, $P=0.11$) at landscape scales. On average, we found that 85% ($\pm$5%) of the total number of exotic species in the sampling plots of a given management area could be found in riparian zones, while only 50% ($\pm$8%) were found in upland plots. We conclude that: (1) species-rich and productive riparian zones are particularly invasible in grassland ecosystems; and (2) riparian zones may act as havens, corridors, and sources of exotic plant invasions for upland sites and pose a significant challenge to land managers and conservation biologists.

**Related Papers and Manuscripts:**


Kalkhan, M.A., Stohlgren,T.J. and Coughenour, M. 1995. An investigation of biodiversity and landscape-scale Gap patterns using double sampling: A GIS approach. p. 708-712. In: Proc. of the Ninth Conf. on Geographic Information Systems. Vancouver, B.C., Canada.

Kalkhan, M.A., Reich, R. and Stohlgren, T.J. 1997. Assessing the accruacy of Landsat thematic mapper classification using double sampling. *International Journal of Remote Sensing* (In Press).

Stohlgren, T.J., Falkner, M.B. and Schell, L.D. 1995a. A modified-Whittaker nested vegetation sampling method. *Vegetatio* 117:113-121.

Stohlgren, T.J.,Binkley, D., Veblen T.T. and Baker, W.L. 1995b. Attributes of landscape-scale, long-term studies: malpractice insurance for landscape ecologists. *Environ. Monitoring and Assess.* 36:1-25.

Stohlgren, T.J.,Quinn, J. F., Ruggiero, M. and Waggoner, G. 1995c. Status of biotic inventories in U. S. National Parks. *Biological Conservation* 71: 97-106.

Stohlgren, T.J. 1997. The Rocky Mountains. In National Status and Trends Report. USDI BRD/USGS (National Biological Service), Washington, D.C. (In Press).

Stohlgren, T.J., Chong, G.W., Kalkhan, M.A. and Schell, L.D. 1997a. Rapid assessment of plant diversity patterns: a methodology for landscapes. *Ecol. Monitoring and Assess.* (In Press).

Stohlgren, T.J., Coughenour, M.B., Chong, G.W., Binkley, D., Kalkhan, M., Schell, L.D., Buckley, D. and Berry, J. 1997b. Landscape analysis of plant diversity. *Landscape Ecology*. (In Press).

Stohlgren, T.J., Chong, G.W., Kalkhan, M.A. and Schell, L.D. 1997c. Multi-scale sampling of plant diversity: effects of the minimum mapping unit. *Ecol. Appl.* (In Press).

Stohlgren, T.J., Binkley, D., Chong, G.W., Kalkhan, M.A., Schell, L.D., Bull, K.A., Otsuki, Y., Newman, G., Bashkin, M. and Son, Y. 1998a. Exotic plant species invade hot spots of native plant diversity. *Ecology* (In Press).

Stohlgren, T.J. 1998b. Scale-dependency in studies of plant diversity. *Integrative Biology: Issues, News, and Reviews* (In Review).

Stohlgren, T.J., Schell, L.D. and Vanden Heuvel, B. 1998c. Grazing effects on native and exotic plant diversity in the Intermountain West. *Ecological Applications* (In Review).

Stohlgren, T.J., Bull, K.A., Otsuki, Y., Villa, C. And Lee, M. 1998d. Riparian zones as havens for exotic plant species in the central grasslands. *Plant Ecology (Vegetatio)* (In Review).

**Other Publications and Manuscripts:**

Falkner, M.B. and Stohlgren, T.J. 1997. Evaluating the contribution of small parks to regional biodiversity. The *Natural Areas journal* (In Press).

Ferreira, L.V. and Stohlgren, T.J. 1997. Effects of river level fluctuation in species richness, diversity, and plant distribution in a floodplain in Central Amazonia. *Oecologia* (Conditionally accepted).

Regan, C.M. and Stohlgren, T.J. 1997. Characteristics of old-growth mixed conifer forests in a southwestern landscape. *Ecological Applications* (In Review).

Regan, C.M. and Stohlgren, T.J. 1997. Old-growth forest extent in a late nineteenth century southwestern landscape. *Landscape Ecology* (In Review).

Stohlgren, T.J. 1998. Data Acquisition for Ecological Assessments. Invited Book Chapter, "Ecological Assessments." Bougeron, P. (Eds). Springer-Verlag (In Review).

Stohlgren, J.J., Bachand, R.R., Onami, Y. and Binkley, D. 1997. Species-environment relationships and vegetation patterns: effects of scale and tree life-stage. *Plant Ecology* (In Review).

Stohlgren, T.J., Chase, T.N., Pielke, R.A., Kittel, T.G.F. and Baron, J. 1997. Evidence that local use practices influence regional climate and vegetation patterns in adjacent natural areas. *Global Change Biology* (In Review).

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