

ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION

STUDY PLAN REVIEW, APPROVAL, AND DISTRIBUTION

Project: RM-4351
Project Location: Albuquerque, NM
Study No.:

Problem: Restoration of Degraded Semiarid Rangelands
Study Title: Ecology of Fire in Semiarid Grasslands
Author(s): Samuel R. Loftin, Research Ecologist
Date Prepared: June 23, 1995

REVIEWED BY:

6-26-95 (Statistical) Signature Date
Rudy M. Y., 8/5/95
Station Biometrician
(Technical)

APPROVED BY:

STUDY PLAN DISTRIBUTION RECORD

<u>Office or Person</u>	<u>Location</u>	<u>Date</u>

RIO GRANDE BASIN RESEARCH - PROBLEM 1

STUDY PLAN

Study Title:	Ecology of Fire in Semi-arid Grasslands
Investigators:	Samuel R. Loftin Rocky Mountain Forest and Range Exp. St. Albuquerque, NM 87106
Collaborating Scientists:	Carleton S. White University of New Mexico Albuquerque, NM 87131
Other Collaborators	Cibola National Forest, Sandia Ranger District City of Albuquerque, Open Space Division and Public Works Dept./Hydrology National Park Service, Petroglyph National Monument Richard Heggen, Ph.D., University of New Mexico

Introduction

Fire! Just the word produces strong emotions in almost everyone. However, emotions need to be tempered with facts, and it is the lack of facts about the effects of fire in semi-arid grasslands which have lead to problems associated with their management.

In the Middle Rio Grande Basin, the Plains-Mesa Grasslands and Desert Grasslands converge with other vegetative communities (Dick-Peddie 1993). These grasslands occur in semi-arid (or semidesert, Brown 1982) environments where annual precipitation ranges between 250 mm and 450 mm, 50% of which occurs in the summer season (June-September). It is this predictable seasonality in part that enables the perennial grass production rather than desert or chaparral shrubs.

In semi-arid grasslands, shrub and tree invasions have occurred since the extensive grazing during the 19th and early 20th century (Conley, Conley, and Karl 1992). Grazing disturbance of the grasslands leads to reduced and dispersed fuels, which made fires less frequent. Even without grazing impacts, fire suppression encourages shrub invasion, which replaces dominant, soil-binding perennial grasses such as black grama grass (*Bouteloua eriopoda*) and tobosa grass (*Hilaria mutica*) with shrubs such as mesquite (*Prosopis juliflora*), juniper (*Juniperus*), burroweed (*Isocoma tenuisecta*), snakeweed (*Gutierrezia sarothrae*), and four-wing saltbush (*Atriplex canescens*) (Brown 1982). Burroweed and snakeweed in particular have replaced grasslands on millions of acres in the

Southwest (Brown 1982). Even on places where grazing by domesticated animals has been eliminated (as on the Sevilleta National Wildlife Refuge), natural replacement of shrubs with grass is slow to occur.

The major problems associated with the conversion of grasslands to shrublands are a loss of forage production and an increase in surface runoff and soil erosion. Perhaps the most significant role of vegetation is in control of hydrological processes. Typically, shrublands have lower rates of precipitation infiltration and higher rates of runoff, which often carries high loads of suspended sediments and associated nutrients. On a larger scale these processes increase inputs of runoff from uplands to drainages and result in arroyo formation, decreased surface water quality, and sediment transport and deposition in rivers, lakes, and reservoirs. Conversion of shrublands to grasslands should retain more water on site and reduce runoff and erosion. For example, a study of sediment yield from the Rio Grande Tributary Basins (prepared by Resource Technology, Inc. for the U.S. Army Corp of Engineers, 1994) included Palo Duro Canyon, which lies mostly within the Sevilleta National Wildlife Refuge. Their analysis shows the total sediment load from this tributary to be consistently lower than predicted from the regression for a basin of that size. The majority of this tributary is ungrazed with relatively high perennial grass cover which makes this unique in this respect among the studied tributaries. Whether or not the apparent low sediment load from that tributary is mostly due to grass cover or from other reasons is unknown, but the possibility of such control would have great implications with respect to runoff, sediment, and non-point source contributions to the Rio Grande. Fire, which consumes shrubs and promotes grasses, may be an essential management tool for restoring and maintaining semi-arid grasslands. The greatest benefit from fire management may be the effects on vegetation composition and subsequent indirect effects on semiarid rangeland hydrology.

The potential for the use of prescribed fire as a management tool is supported by the fact that grassland/shrubland fires are becoming increasingly common in this area. Lightning ignited fires are now common in New Mexico grasslands that have been removed from grazing, as is the case with the grasslands proposed for this study. On the Sevilleta National Wildlife Refuge, lightning-ignited fires are occurring with increasing frequency. Following removal of domesticated grazing animals, the grass and fuels to carry a fire have increased. In 1989 and 1990 alone, there were three lightning-ignited fires that were large enough to be easily recognized from satellite images; one on 6/22/89, a second on 6/19/90, and the third on 6/29/90. A large range fire occurred on Pueblo of Isleta grasslands on the east mesa during the summer of 1993. City of Albuquerque Open Space property (one of our proposed study sites) has had two fires that resulted in response by the fire department. Thus, fires are a real part of these systems and the potential to use fire as a management tool exists on most public grasslands in this region.

Objectives

The objectives of this project are to evaluate the effects of prescribed fire on the composition, productivity, and abundance of the vegetation, the nutrient and water dynamics of the soils, and the surface hydrology of two grassland sites in the Middle Rio Grande Basin.

Specific questions to be addressed by this design are: 1) Does a single prescribed fire significantly alter the cover and species composition of these semiarid grasslands? 2) Does a single prescribed fire significantly alter soil organic carbon, total nitrogen, and total phosphorus? 3) Does a single prescribed fire significantly alter the surface hydrology of these semiarid grassland sites?

This study should be important to all agencies and individuals that manage semiarid grasslands. We will generate information on the effects of fire on vegetation productivity, soil stability, and water quality. If this treatment proves beneficial it could be incorporated into management plans for semiarid grasslands and potentially improve ecosystem health and sustainability.

Experimental Design and Methods

A coordinated experimental design is proposed for use at the two potential study sites (Fig. 1). One site is on City of Albuquerque Open Space near the shooting ranges (and Double Eagle Airport) on the West Mesa and the second site is on the Cibola National Forest - Bernalillo Watershed (outside of the Research Natural Area). Grazing by domesticated animals is not allowed at either site. The Open Space grassland represents a Great Basin Desertscrub/Desert Grassland ecotone and the Bernalillo Watershed represents a Plains-Mesa Grassland/Desert Grassland ecotone. Both sites have a substantial shrub component. The experimental design has four experimental plots to be treated with prescribed fire and four experimental control plots at each of the two sites. Pairs of experimental plots are blocked and randomized in order to help correct for potential environmental gradients. Each experimental plot will be 100 m on a side, with a 30 m border between plots (Fig. 2).

Community Structure Analysis (Pase, 1981) will be used to monitor changes in vegetation abundance and composition. Three 100 m CSA transects will be established within each experimental plot.

Soil profile descriptions (1.5 - 2.0 m) to be conducted by Cibola National Forest personnel will provide valuable baseline data on soil development. Surface soil samples (0 - 20 cm) will be collected from three 60 m belt transects established within each experimental plot. Surface soils from three different cover types (shrub, grass, and bare soil) will be monitored for changes in total carbon, total nitrogen, total phosphorus, and soil mineralization potential which is a measure of potential nitrogen availability. One composite sample, with three to six subsamples per composite, will be collected for each cover type in each of the

sixteen treatment plots. This sampling design will permit a detailed analysis of the effects of fire on the distribution of soil resources.

Two 3 X 10 m runoff plots will be established within each experimental plot. Runoff plots will be similar to those used by Aguilar and Loftin (1992) but with a modified runoff collection design. Surface runoff will be quantified and analyzed for total sediment, total phosphorus, total nitrogen, mineral nitrogen, and salt content (conductivity). The City of Albuquerque personnel, among others, are very interested in the data generated from the hydrological study which will be used to test (and perhaps modify) the hydrological model described in Section 22.2 of the Development Process Manual of the City of Albuquerque.

Changes in soil water will be monitored using a Troxler non-nuclear soil water probe for depths from 10 - 100 cm, and a Trase TDR probe for depths from 0 - 15 cm. Soil erosion bridges will be established to monitor changes in soil surface microtopography.

The prescription developed for burns on the Sevilleta Wildlife Refuge by the Fish and Wildlife Service may be available and appropriate. The prescribed burns will be conducted by collaborators such as the Cibola National Forest and the National Park Service.

Sampling techniques and data management responsibilities will follow those utilized by the Sevilleta LTER program (Carl White is LTER Laboratory Director) and standard practices followed by the Rocky Mountain Station.

Depending on conditions, the prescribed burns will occur in the spring or fall of 1995. Following the burns, soils and vegetation will be sampled annually in the fall, erosion bridges will be sampled at least twice a year, and soil water will be sampled monthly.

Statistical Analyses and Data Management

Standard statistical analyses will be used to test for significant treatment effects. Data sets with multiple sampling periods will be analyzed with a repeated measures design to correct for lack of sample independence. Data will initially be analyzed with a MANOVA design to test for significant major factors (site, time, treatment). Subsequent analyses (ANOVA and t-tests, when appropriate) will test for within-site and across-site treatment effects.

Responsibility for data archival rests with those who initially collect the data, however, complete, fully documented sets of data will be stored at both the University of New Mexico, Dept. of Biology, and the Rocky Mountain Forest and Range Experiment Station, Albuquerque, NM. Statistical Analyses will be conducted by both institutions, following procedures reviewed by the RMFRES Biometrics staff. All data will be available to the principal investigators. Publication of results is the responsibility of the principal investigators.

Future Research

The experimental design is presented in two parts; the overall conceptual design and the initial experiments proposed for the first year. The overall conceptual design includes evaluation of the effects of a single fire in these grasslands. The experimental design of this project could be modified and/or expanded to include other factors that may produce different results. A second factor, which takes advantage of the unique ecological character of New Mexico, is the seasonal effect of fire. It has been shown that in tallgrass prairies a cool season fire favors annuals and C_3 grasses, whereas a warm season fire favors native perennial C_4 grasses. Similar results may occur in semiarid grasslands. Surrounding Albuquerque are examples of different grasslands with C_3 and C_4 species, which allows cross-ecosystem comparisons between grasslands to be effected here at a fraction of the cost to conduct elsewhere. A third factor would be the return interval for fire in grasslands. Annual fires are unlikely in semi-arid grasslands due to lack of fuels. Prior to Anglo settlement, a close linkage may have occurred between fire interval and the El Nino/La Nina oscillation. Fuels would be near maximum following an El Nino (wet part of cycle), which would increase the probability of fire in these systems. Thus, return intervals may vary from every other year to the 3 to 7 year return interval of the El Nino.

It is expected that this project could evolve into a very high profile experiment with considerable publicity. All effort would be made to acknowledge the participation of all involved interests. Publications resulting from this research would acknowledge contributions by all interests (and/or appropriate disclaimer). Some publications may be authored by individuals, but it is anticipated that all collaborators would be co-authors on appropriate publications.

Application of Research Results

Multiple agencies and personnel with multiple disciplinary backgrounds will collaborate on this project. The project will be conducted by researchers from the Rocky Mountain Forest and Range Experiment Station and The University of New Mexico, Department of Biology. Potential collaborators include (listed on cover but not restricted to): Sandia Ranger District, Cibola National Forest; City of Albuquerque, Open Space Division; and the Petroglyph National Monument, National Park Service. The degree of involvement will be dependent upon the interest and resources available to each collaborator.

Many different scientists representing different disciplines have expressed interest in participating in this research. Sam Loftin, Research Ecologist with the Rocky Mountain Station, will be researching plant community dynamics and species composition. Nutrient cycling and site fertility indices will be studied by Carl White at the University of New Mexico. Changes in infiltration and runoff relationships, soil erosion, nonpoint source sediment production, and runoff water quality will be studied by Steve Hofstad, a graduate student in the Master of Water

Resources Administration Program (Carl White is his major advisor). Legal and Policy issues surrounding the use of fire will be studied by Yorgos Marinakis (pending funding), a third-year Law Student and a collaborator on other research projects with Carl White.

We anticipate 2 - 3 refereed journal publications in the next 2 - 3 years as a result of this research. Potential journals would include Ecology, Ecological Applications, Water Resources Research, and Journal of Range Management. The results of this research will also be presented at regional and national societal meetings and symposia.

Safety and Health

Potential safety and health hazards connected with this study are those normally associated with highway safety and field work in semiarid and arid rangeland environments. Additional health and safety precautions will be taken during the prescribed burns. US Forest Service and US National Park Service Fire Crews will be on hand during the prescribed burns. There is no anticipated use of heavy equipment or hazardous chemicals. We will not be directly involving wildlife or domestic animals in any experimental phases of this proposed work.

Environmental Impact

No detrimental treatment of wildlands is contemplated. The research activity in this study is of limited context and has minimal negative impact on the environment.

Research Itinerary (Fiscal Year 1995)

Experimental Plot Establishment	April - May 1995
Pretreatment Sampling	May 1995
Prescribed Burns*	June 1995
First Post-treatment Sampling	June 1995
Second Post-treatment Sampling	Sept.- Oct. 1995

Soil water will be monitored monthly, erosion bridges will be monitored at least semi-annually, and vegetation and soils will be sampled annually.

*Environmental conditions may necessitate a fall burn in which case the itinerary will be pushed back approximately six months.

Rocky Mountain Station RWU 4351

Personnel (Technical Support - 2 wks) \$ 1,000

Soil Analysis

(1 sample)(3 cover types)(3 transects)(16 plots) = 144 samples

Organic Matter (\$2.75)(144) = \$ 396

Total Nitrogen (\$6.00)(144) = \$ 864

Soil Analysis Subtotal \$ 1,260

Travel

GSA Vehicle Use (6 months) \$ 2,250

Meetings \$ 583

Travel Subtotal \$ 2,833

Materials and Supplies

Runoff Plots

Galvanized Flashing \$ 853

Plastic Rain Gutters \$ 214

Additional Supplies \$ 1,092

Aluminum Stakes

CSA (6/plot)(16) = 96 \$ 245

Soil Transects (12/plot)(16) = 192 \$ 490

Erosion Bridges (10/plot)(16) = 160 \$ 392

Rebar Stakes

Runoff Plots (1/2" X 1') (25/plot)(16) = 400 \$ 213

Erosion Bridges (3/4" X 2') (20/plot)(16) = 320 \$ 405

Troxler Access Tubes

Schedule 40 PVC (4/plot)(16) = 64 X \$3.00 \$ 192

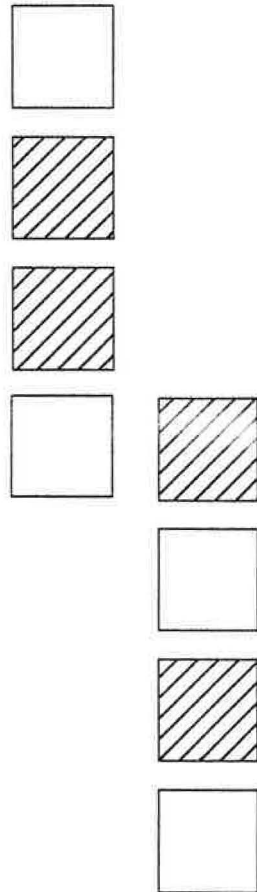


Materials and Supplies Subtotal	\$ 4,096
UNM Total	\$21,055
Personnel	1,000
Soil Analysis Subtotal	\$ 1,260
Travel Subtotal	\$ 2,833
Materials and Supplies Subtotal	\$ 4,096
GRAND TOTAL	\$30,244
GRAND TOTAL LESS UNM IDC	\$23,415

Literature Cited

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West Mesa



Bernalillo Watershed

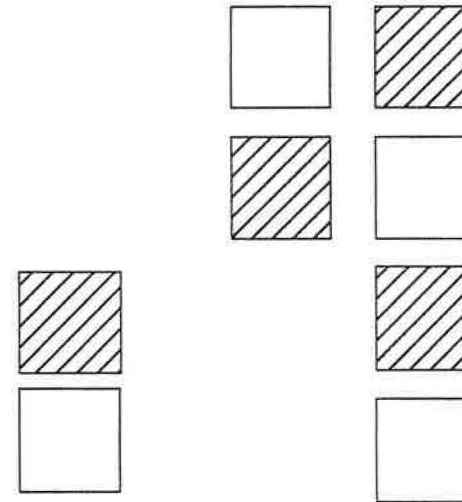


Figure 1. Experimental design for the West Mesa and Bernalillo Watershed study sites. Each site has eight 100 X 100 meter plots, half of which will be burned (shaded)

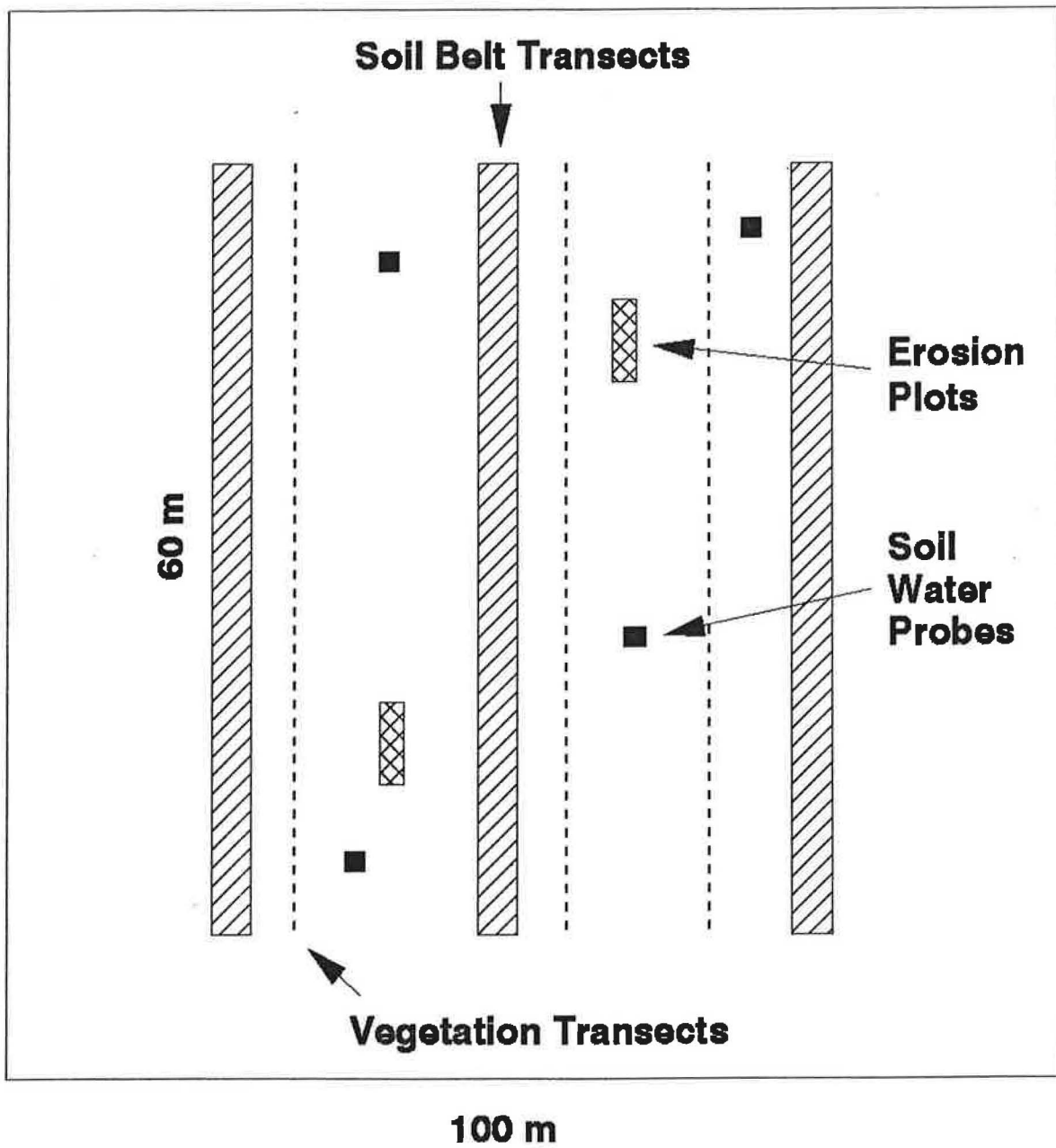


Figure.2. Experimental plot design with three (5 X 60 m) soil belt transects, two (3 X 10 m) erosion plots, three (60 m) CSA transects, and four Troxler soil water access tubes.