Work Plan for Rocky Mountain Research Station

RMRS 02-JV-11221615-123

Experimental Studies of the role of fire and interactions with grazing in restoring and maintaining semi-arid grasslands

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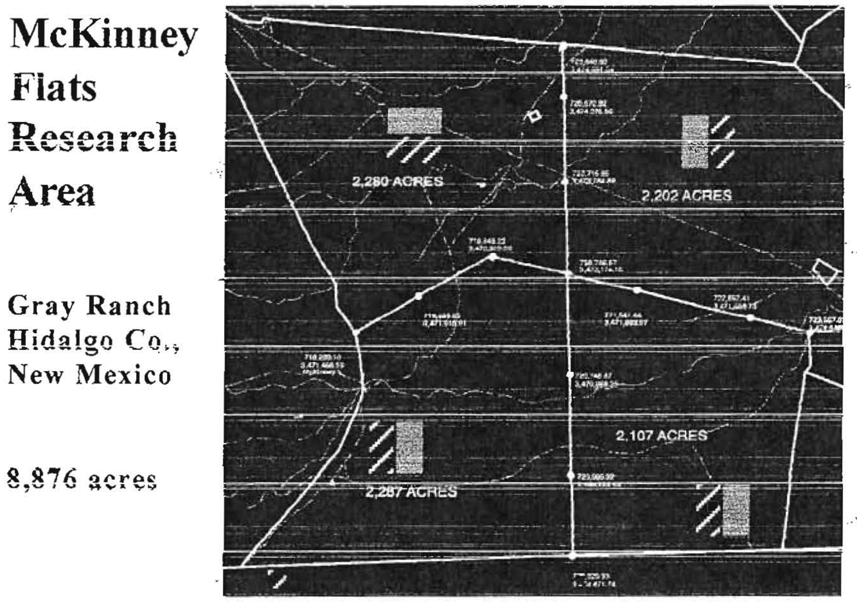
II. **Problem reference**. RMRS-4651-2.

III. **Literature**. Historical writings, old photographs and paintings and paleo-ecological studies document changes typical of desertification (e.g. increases in woody vegetation and declines in grasses) throughout the arid regions of the southwest within the past 150 years (Hastings and Turner 1965, Cook and Reeves 1976, Grover and Music 1990, Bahre 1991). Data from long-term ecological studies and remote sensing indicate that these changes have continued, and in some cases accelerated, in the last 25 years (Ray 1995, Swetnam and Betancourt 1998, Curtin and Brown 2001). These increases in woody vegetation have two fundamental implications for fire dynamics in the southwest; 1) they can either increase fuel availability and fire intensity, or 2) they can reduce fine fuels and retard fire spread. Either scenario seriously disrupts the historical fire regime. While fire and grazing have been a long-term concern for land managers in the southwest (Leopold 1924), and some good comparative studies exist (Ffolliot et al. 1996, Tellman et al. 1998), there are no replicated, long-term landscape studies of fire and its interaction with herbivory (Curtin 2002). Land managers have little guidance when it comes to understanding the ecological implications of suppressing, or managing for fire, in arid grasslands. Our study provides perhaps the first opportunity to document in an experimental setting the effects of fire and its interaction with grazing while offering land managers the experience of directly observing the relative effects of fire in grazed, and ungrazed landscapes.

IV. **Objectives**. The objective of this study is to determine the effects of fire and grazing (native herbivore and livestock), both singularly and in combination, on the structure and composition of arid grasslands. The goal of generating this information is three fold. First, to document the effect of fire and the interaction of fire with herbivory in arid grasslands and to disseminate this information through peer-reviewed articles, book chapters, and conference proceedings. Second, to serve as one piece in an integrated research program that guides conservationists and land managers in sustaining the ecological health of borderlands ecosystems. Third, to provide a demonstration site where public and private land managers can come and observe the relative effects of these processes on arid grasslands.

V. **Methods**. Upper elevation Chihuahuan Desert grasslands are considered one of the most biologically diverse and most imperiled grasslands in the world (Dinerstein et al. 2000). Within the Chihuahuan desert fire and grazing are regular and frequent disturbances that have a profound influence on structuring these grassland ecosystems. The effects of both are inextricably linked and it is not appropriate to consider the effects of one without considering its implications for effects of these processes at small scales are not likely to accurately reflect the impacts of these disturbances at their realistic and appropriate scales. However, we do not know of a single replicated study of the effects of fire and its interaction with traditional land-use practices (e.g. livestock grazing) at a landscape scale. Our 8,876 acre fire research site on the Gray Ranch in southwestern New Mexico provides a rare opportunity to conduct controlled, replicated experiments on the effects of fire, and its interaction with grazing, at scales consistent with landscape scale processes (Figure 1). A study of this magnitude is also an unprecedented opportunity to provide a demonstration site at which land managers can view the effects of fire and its interaction with grazing in a context relevant for making land management decisions.

Figure 1.



Blue = Grazed Plots

Striped = Fenced Grazing Exclosure

The basic tenant of the Gray Ranch fire/herbivory studies are to determine what is the minimum scale at which the interaction of the major variables affecting grassland plant and animal species can be studied. This results in what we believe to be a true landscape approach consisting of studies organized around a hierarchy of scales. This meant we had to respond to the following constraints: a) We needed an area large enough to observe fire at an appropriate scale on the land,

b) We needed an area large enough to replicate the rotational grazing regimes considered sound livestock management in the region, c) We needed a research site large enough to incorporate home ranges and foraging areas for investigating the interactions of a number of organisms including birds, rodents, lizards, and invertebrates, d) We needed enough homogeneity between replicate study blocks in order to provide meaningful comparisons. Given our basic question we believe the use of four 2,200 acre (916 ha.) sub-pastures, each containing a 1 x 1 km square study block with four 200 x 200 m plots within each block, is an appropriate scale at which to conduct our study. Each block is large enough to apply experimental treatments at an appropriate landscape scale, yet small enough to serve as like replicates without losing homogeneity while maintaining enough separation between vertebrate population samples to have true replication. By conducting our study on private lands we have the flexibility to manipulate the landscape unavailable if we had placed the study on federal lands.

Study Area

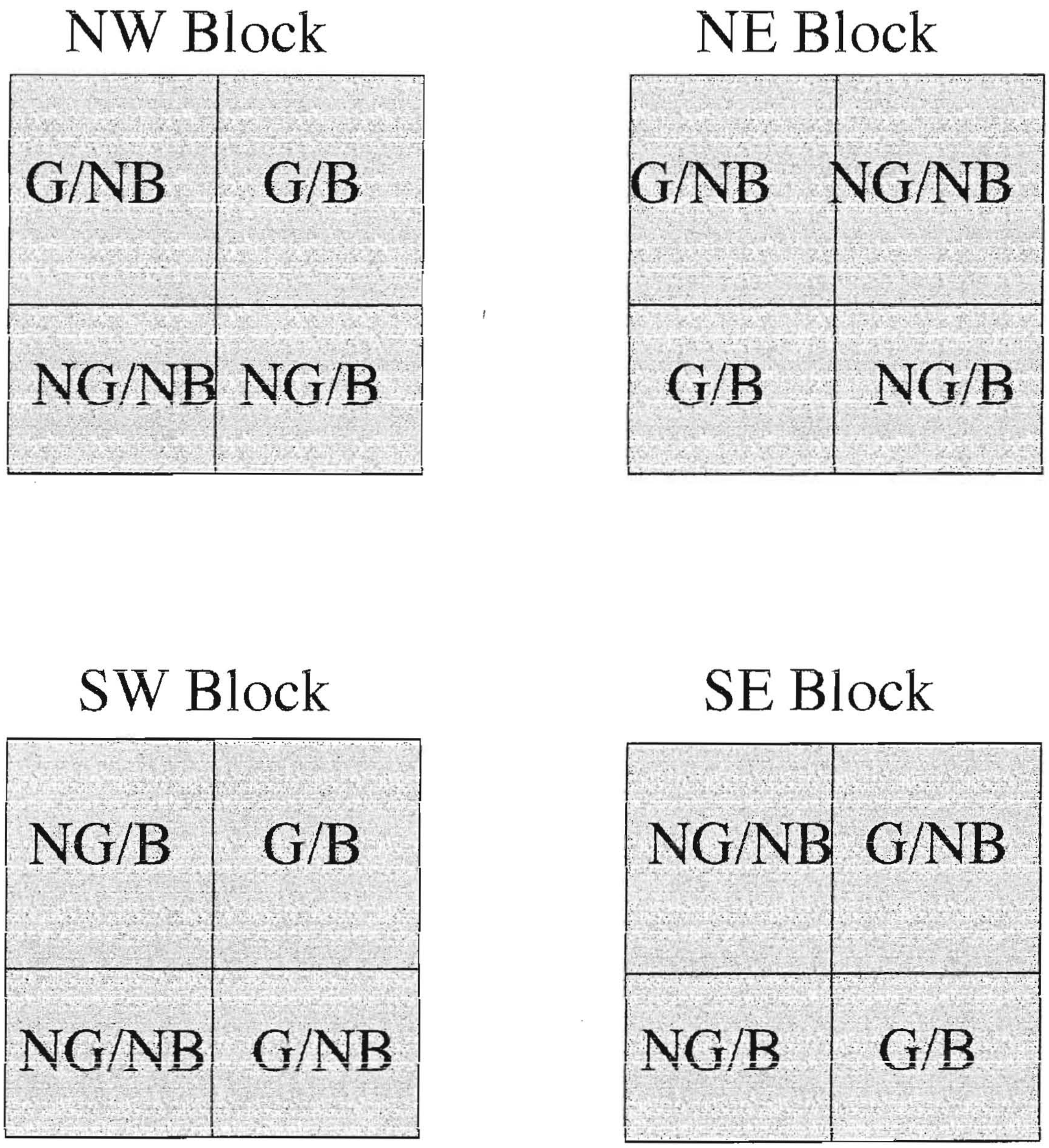
Our study site is located on the 502 square mile Gray Ranch managed by the Animas Foundation. The Animas Foundation has set aside the 8,876 acre McKinney Flats pasture as a research area. Ungrazed since 1991, the McKinney Flats pasture is located at an elevation of 1650 m. It contains a gradient from Plains-Great Basin grasslands (Bouteloua association), to semidesert grasslands (Bouteloua-Hilaria-Sporobolus association), to Chihuahuan Desert grassland/shrubland (Prosposis association).

Experimental Design

The fundamental underpinning of our research design was the need for independent replication of study plots (Hurlbert 1984, Hairston 1989). This means that there must be a minimum of four replicates of each treatment, and each treatment must, while being comparable to other in biotic and abiotic components, be independent of the others (Figure 2). Statistical analysis can be conducted through ANOVA with each study block and plot an independent replicate, or via regression using a split-plot design.

Figure 2.

Plot Diagrams

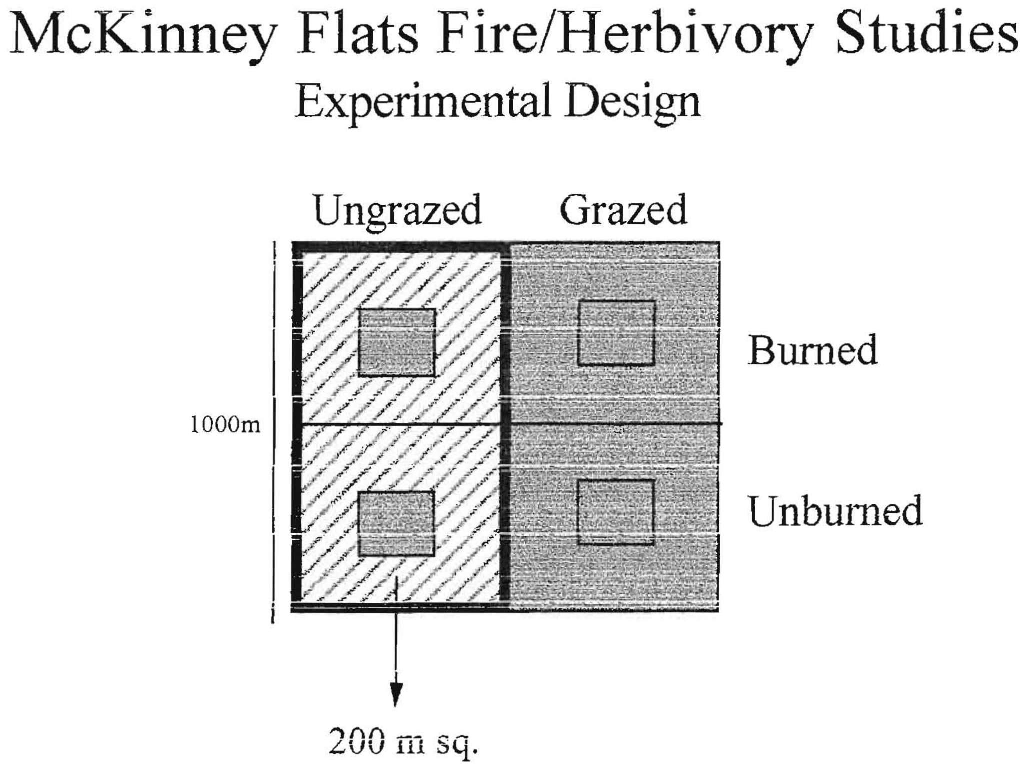


GB =Grazed/Burned
NG/B = Not Grazed/Burned
G/NB = Grazed/Not Burned
NG/NB = Not Grazed/Not Burned

Initially we had intended to place our grazing treatments in an ungrazed matrix. Yet, we realized that the necessary scaling of this system would result in high intensity, short duration grazing which would not be representative of regional range management practices. Instead we have gone to a four pasture, rest rotation system that is more representative of progressive range management in the region. Each pasture serves as an independent grazing replicate. The solid lines represent pasture boundaries (Figure 1). Burns will also be conducted in the context of each sub-pasture to attain replication of fire treatments.

Within each of the pastures 1 x 1 km. study areas were established. In addition to the proximity to other plots, other constraints on plot placement were the selection of comparable soil and vegetation zones, topography, and distance to a water sources (to avoid this confounding variable we determine that the plots should be at least 1 km from permanent water).

Figure 3.



Within each block are four treatment plots: a) grazed-unburned, b) grazed-burned, c) ungrazed-unburned, and d) ungrazed-burned. Each of these 200 x 200 meter treatment plots were placed as close as possible to the center of the 500 x 500 m blocks to reduce edge effects and maximize distance between samples within each study area (Figures 1, 2 and 3). Each stake on every plot has an aluminum tag listing it's location to insure that data locations are properly designated.

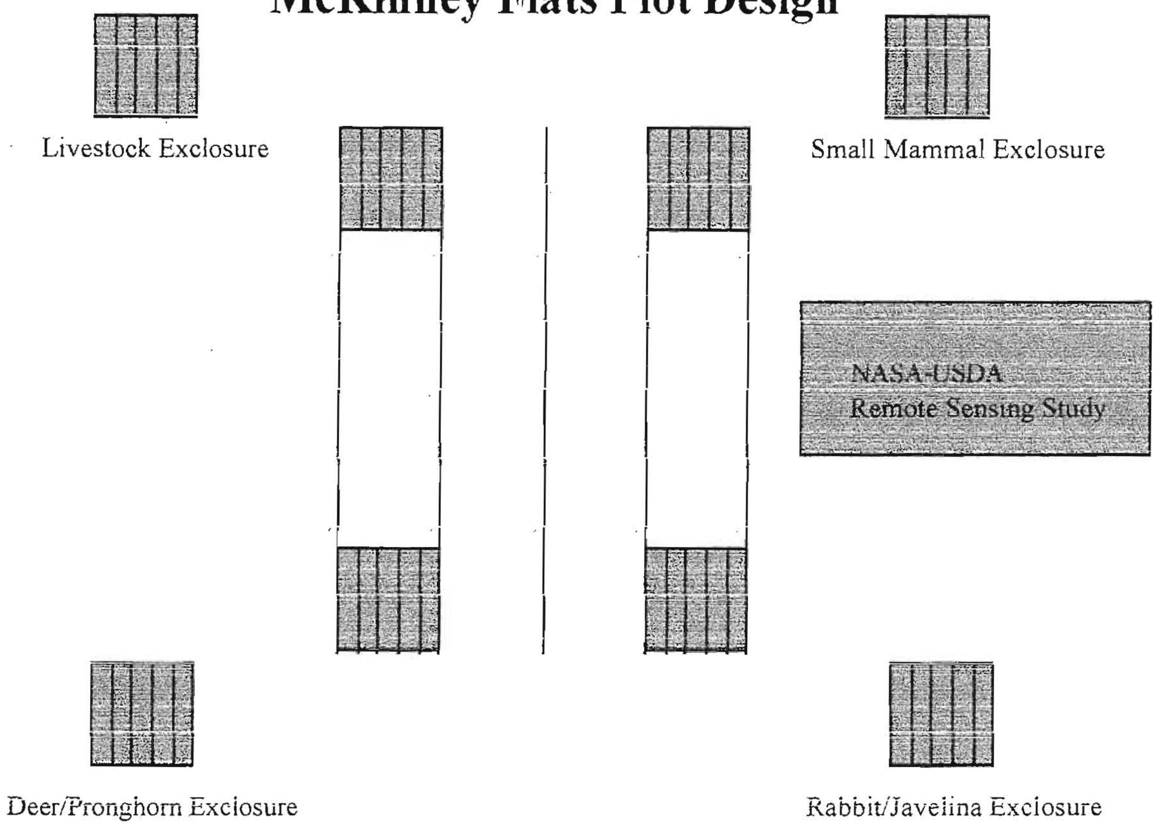
Vegetation Monitoring: The vegetation monitoring protocol was arrived at through consultation with a number of biologists with long-term experience in desert grasslands and the Gray Ranch including range scientists and ecologists James Brown, Don Dwyer, Pete Sundt, and Raymond Turner. A number of scaling and data collection exercises were conducted by botanist Myles Traphagen to determine when sample sizes asymptote and what the minimum necessary sampling intensities are. Additionally, a rigorous field analysis of some commonly used range monitoring protocols, compared with our own, was conducted this past spring. This research, supported by the Turner Foundation, indicates that our protocol is the most robust and accurate at detecting change in grassland communities of any technique we know of currently in use in the Southwest (Traphagen and Sundt, In preparation). Thus one important outreach facet of our work has been the improvement of vegetation monitoring protocols and communicating the techniques of these improved protocols to scientists and land managers in the Southwest. This has particularly important implications to government agencies that have been relying heavily on dated and inaccurate monitoring protocols as the basis for their management decisions.

Our sampling protocol entails using 40 x 40 cm. quadrates set at two meter intervals along ten 150 meter sampling lines. Plot and block locations are GPS'ed and mapped to assure they can be found, even if stakes are removed. This information is filed at Arid Lands Project offices in Maine and Animas Foundation headquarters at the Gray Ranch. Relative frequency data is obtained for each 150m transect by using a series of 75 quadrates systematically placed at 2m intervals along the transect. Relative cover data is obtained by using the four corners of each frequency quadrate as one point-intercept data point resulting in 300 points per transect and

3000 points per 150 x 150 m plot. These plots are sampled following the summer growing season each year (Figure 4).

Figure 4.

McKinney Flats Plot Design



At the corners of each 150 x 150 m plot are four 36 x 36 m plots that are sampled at three to five year interals bepending on climate and disturbance. These plots provide additional replication and statistical power for measuring vegetation responses at a smaller scale and are comparable in size to mammal exclosures adjacent to each of the study plots (Figure 3). This has the added benefit of allowing these plots to serve as controls for the small mammal exclosure studies (discussed below).

The 36m x 36m plots are comparable to studies being conducted on the Jornada and Sevilleta Long-term Ecological Research Sites in New Mexico, the Armendaris Ranch in New Mexico, and the Mapimi Biosphere reserve in Durango, Mexico. The small mammal exclosures involve 36 x 36 m. small mammal exclosures (hardware cloth), rabbit/javelina exclosures (Chicken Wire), Deer and antelope exclosures (three-strand barb-wire), and cattle exclosures (five-strand barb-wire)(Figure 4). Vegetation sampling of the mammal exclosures is conducted on each pasture every three seasons prior to that pasture being burned. To track the dynamics of larger woody species such as mesquite, agave, and yucca, low level aerial photography will be used. Biomass data is collected at each sampling stake on each plots once yearly following the end of the summer growing season. The protocol followed is that developed by Robin Marsett at the USDA-ARS in Tucson, Arizona and is available from the Arid Lands Project,' vegetation sub-contractor Myles Traphagen, or from Dr. Marsett at ARS offices

Small Mammals: Three times a year Sherman traps are placed one meter to the east of the base of the orange 7/16 inch fiberglass stakes located at 30 m. intervals along the five 150 meter transects. This sampling coincides with the lizard sampling to more efficiently use resources and to make lizards and rodents as comparable as possible. In addition some of the smaller species that are not often collected in the Sherman traps, fall into the lizard pitfall traps, increasing the extent of our data. We have found that to ensure the traps are all picked-up by the heat of the day, that only one-half of the site will be trapped at a time (240 traps per night). The duration of trapping is three days in each location. Due to relatively high mammal densities and diversities on the site (roughly 12 species on the site at a given time and two to ten captures per 200 x 200 m sampling area), this approach is proving effective at documenting small mammal species composition. Base-line data was collected once a year from 1998 to 2000. Following completion of initial grazing treatments in 2002, we will go to three small mammal trapping sessions each year conducted in conjunction with the summer reptile censuses. After capture species, sex, weight, body and tail length, and hind foot length are measured.

Reptiles/Amphibians: Based on a number of years of research experience in arid grasslands New Mexico State Herpetologist Charlie Painter recommended pitfall traps for reptile and invertebrate sampling. In order to facilitate direct comparison between lizard and mammal populations, we have elected to place pit-fall traps along the same mammal trap lines one meter west of the stakes used

for small mammal sampling. Pit-fall traps are censused three times yearly for three days each (totalfield time is 9 days to allow for lizard processing and data collection).
These periods include the late spring, after adults emerge and become active (early May), in early summer before the hot dry periods prior to the monsoon (early June), and in late July/early August after the monsoon (when heat and drought sensitive species are likely to be active). Three lizard samples were completed in 2000 and 2001. After captured the following data on lizards is taken: species, weight, sex, Snout-vent length, tail length and condition, and morphometric measurements to analyze changes in body size. All animals are individually marked through a system of toe clips. Data sheets and information on toe clips is available from Arid Lands Project offices or from New Mexico State Herpetologist Charlie Painter.

VI. **Quality assurance/quality control procedures**: Research on Mckinney Flats has been reviewed by RMRS statistician Rudy King and the Animas Foundation's and Malpai Borderlands Group's science advisors Larry Allen (U.S. Forest Service - ret.), Ron Bemis (NRCS), James Brown (University of New Mexico), Don Dwyer (New Mexico State University - ret.), Carl Edminster (Forest Service Rocky Mountain Research Station), Gerry Gottfried (Forest Service Rocky Mountain Research Station), Rick Knight (Colorado State University), Rich Kvale (Coronado National Forest), Curt Meine (International Crane Foundation), Ray Turner (USGS - ret.), Tom Valone (St. Louis University), Peter Warren (The Nature Conservancy), and David Western (Wildlife Conservation Society - Kenya).

Charles Curtin oversees the overall project. Dr. Curtin has 18 years research experience with study fire and grazing in grassland ecosystems including management of long-term research project for the University of New Mexico from 1995 to 1997 and the McKinney Flats project from 1998 to present. Dr. Curtin is a co-chair of UNESCO's Chihuahua grasslands working group, is the Society for Conservation Biology's representative at the Interagency Sustainable Rangelands Roundtable, and a member of The Nature Conservancy's Aridlands Network. In addition to Dr. Curtin's overall supervision, experienced personnel directly supervise all aspects of field studies. Myles Traphagen who helped design, and has implemented the Mckinney Flat vegetation monitoring will continue to do so in the foreseeable future. New Mexico State Herpetologist Charlie Painter is overseeing the reptile studies and Dr. Curtin oversees the mammal studies. As discussed above, we are not at present conducting bird surveys and will contract with experienced ornithologists before the start of the next field season. All data is filed with the subcontractors, and at Arid Lands Project offices. In addition, the most important aspect of quality assurance is peer review. We complete numerous peer-reviewed papers and presentations each year, and much of our funding comes from competitive grants. This sustains a high quality of science and insures that we continue to meet the standards of our peers and stay up to date with technological developments.

VII. **Application of research results**. Visits by agency personnel, researchers, and private land-managers on the site have been an integral part of our out-reach work since the project's inception. While our studies are conducted on private land we have a number of agency partners who work closely with us. This includes the BLM who supported much of the set-up and initial two years of research costs and continues to assist with controlled burns; the Forest Service Rocky Mountain Research Station who has also supported much of our research financially and who provides logistical support; and the NRCS which is conducting analysis of soil conditions and providing logistical support. We are also working with colleagues from the National University in Mexico City who are establishing a research station 50 km. south of us near Janos, Chihuahua to develop a collaborative research program with Mexican scientists and agency personnel. Many from these organization and numerous others frequently visit our site, for example in 2000 the following groups were given guided tours:

1) Malpai Science Advisory Committee and Visiting Researchers.
2) Local High School Student Groups.
3) Ranching Groups from Around the West, Canada, and Hawaii.
4) New Mexico BLM Resource Advisory Council.
5) The Nature Conservancy Senior Fire Ecologists.
6) Mexican Researchers from the National University in Mexico City.
7) New Mexico Game and Fish Biologists.
8) USFWS Biologists
9) Numerous Journalists.
10) Livestock Managers/Marketers from Meat Livestock Australia.

11) South African Soil and Water Conservation Personnel.
12) Representatives from National Fish and Wildlife Foundation.
13) Agency Meetings and Field Tours with Numerous Representatives of BLM, the Forest Service, NRCS, and USFWS.

As part of our yearly meeting where we invite agency personnel from the BLM, Forest Service, NRCS, USFWS, and state and local land managers to see our research and land management programs we will be holding workshops in the field to demonstrate the effect of fire and its integration with grazing. We have expanded our out-reach activities by putting roads into the center of the research plots to provide access to a viewing area where visitors can directly compare the effects of fire and its interaction with grazing.

In addition to site tours and talks, as discussed above, we frequently publish peer-review papers including two in Conservation Biology last year and provide interviews to the press for popular articles. Articles discussing our work have recently appeared in BioScience, The Nature Conservancy magazine, the New Mexico Game and Fish Bulletin, and the New York Times (Appendix I). We currently have two articles in review on prairie dogs and grazing.

VIII. **Safety and health**. The major threats to field workers are vehicle accidents and heat and dehydration. Only persons licensed and experienced use vehicles and close supervision insure that personnel do not experience dehydration is conducted by research leaders and extra water is provided in the field.

IX. **Environmental analysis considerations**. Since grazing and fire have long been part of grassland ecosystems, these do not directly impact our ecosystems. Perhaps the biggest issue is road access for we strive to reduce foot traffic on the study plots and to avoid all vehicle traffic. Researchers and range management personnel are to only drive on designated roads, walk on designated trails, and are to avoid travel on the site when conditions are wet.

X. **Personnel assignment, time of completion, and cost**. Under the terms of the current agreement, the only personnel involved are the PI and his administrative assistant. A detailed review of costs associated with project administration and data analysis is included in the agreement.

XI. **Data Management**. Myles Traphagan and Charles Curtin each have complete copies of all plant data including both raw data, and excel spread sheets. These are stored in Mr. Traphagen's offices in Davis, California and Dr. Curtin's offices in Maine. Dr. Curtin also keeps excel and original copies of all other project data. In addition, Charlie Painter has original and excel copies of the lizard data. In addition to data held by subcontractors and cooperators, excel data are stored under name by data type and year for all data sets in a fire resistant container, and on Dr. Curtin's Computer.

XII. **Literature cited.**

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Ray, T. W. 1995. Remote monitoring of land degradation in arid/semiarid regions. Ph.D. Thesis, California Inst. of Technology.

Appendix I.

Recent Research Publications Supported by the Arid Lands Project:

Gottfried, G., L. Eskew, and C. G. Curtin, (Eds). 1999. Towards Integrated Research, Land Management, and Land Protection in the Malpai Borderlands. Conference Summary; 6 - 8 January 1999; Douglas, Arizona. Proceedings RMRS-P-10. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, 136 pp.

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Stolzenburg, W. 2000. Good cow, bad cow: a two-headed question over cattle on the range. The Nature Conservancy Magazine June/July. Pp. 12 – 19.

Share with Wildlife Newsletter. Fall 2000. Prairie dog post-reintroduction surveys: reducing woody vegetation encroachment. New Mexico Department of Game and Fish.

MacCarter, J. 2000. Back to nature: restoring processes including fire and prairie dogs, helps keep ranch grass lush. New Mexico Wildlife 45: 2 -5

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