Livestock Research Briefs and 1999 Cattle Growers' Short Course

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College of Agriculture and Home Economics
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RANGELAND RESEARCH IN THE CHIHUAHUAN DESERT

The mission of the Jornada Experimental Range is to develop new technologies for the management and remediation of desert rangelands. Our four general objectives are:

1) **Quantify key ecological processes** that characterize functions of arid rangelands,
2) Identify, evaluate and describe **methods for monitoring** and assessing the conditions of desert rangelands,
3) Design and test **techniques for remediating** degraded desert rangelands, and
4) Develop agricultural practices appropriate for **livestock production in desert environments.**

Ongoing projects addressing these objectives are summarized below. The following diagram (Figure 1) illustrates how we integrate specific research projects within the framework of these objectives.

We have organized this report around these four objectives. Within each objective we have described various research projects using a series of "bullet" statements. Each topic lists a synopsis of current information, the status of our research and its potential applications. The name and email address of a scientist working on a particular topic is listed if you wish further information.

Information on our research program, collaborations, publications, advisory committee membership and other activities can be viewed at our web site: usda-ars.nmsu.edu

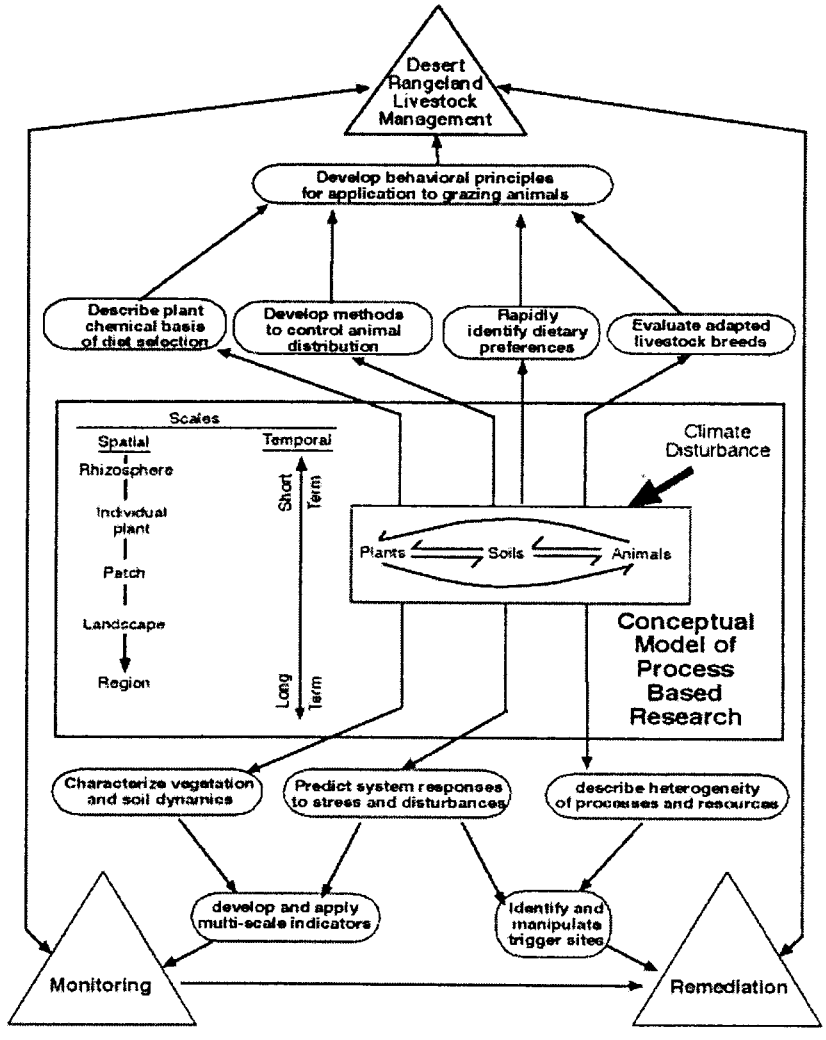

Figure 1. General schematic of the research program at the Jornada Experimental Range. Our central conceptual model incorporates scale and several key research objectives concerning plant-, soil- and livestock-related studies. These coordinated, interdisciplinary and interactive research directions are focused toward our three primary target outcomes of monitoring tools, remediation techniques and livestock management principles.

Desert Ecology

Creosote phytochemistry (Ed Fredrickson; efredric@nmsu.edu)

- Plants compete with other plants, bacteria, fungi, insects and mammals for a limited amount of nutrients.
- Chemicals associated with plants (phytochemicals) can prevent establishment of other plants and/or discourage consumption by animals and insects.
- We examined the distribution of nordihydroguaiaretic acid (NDGA, one of the major chemicals in creosotebush), tannins and other phenolics in leaves, stems, roots, flowers and seeds of creosotebush (*Larrea tridentata*).
- Total phenolics were found mainly in leaves, green stems and roots, while NDGA was present in green stems, leaves and flowers, but tannins were appreciable only in seeds.
- Studies are in progress to determine whether these compounds affect neighboring plants, whether rain removes and redistributes these chemicals, whether compounds are released during microbial decay of litter, and whether these compounds persist in soil and affect nutrient recycling.
- Preliminary indications are that NDGA is not transported in detectable amounts by rain, but total phenolics appear to be higher in rain stemflow than in interplant spaces.
- Collectively, studying distribution of chemicals within a plant and transfer into soil will help us understand aspects of desert ecology related to plant competition and survival.
- For example, phenolics in roots or soil may have allelopathic effects on surrounding plants, deter below ground herbivory, or affect soil microbes and/or fungi, while tannins in seeds may be involved in seed dispersal.

Root fungi (Jerry Barrow; jbarrow@nmsu.edu)

- Fungi live in association with roots of many desert plants, including fourwing saltbush (*Atriplex canescens*).
- We previously identified a symbiotic fungus that solubilizes and transports phosphorus to fourwing saltbush seedlings and increases their growth and chance for survival.
- These symbiotic fungi improve the ability of saltbush to access water and nutrients in organic matter that are necessary for germination and establishment.
- In turn, the plant supplies fungi with carbon for growth and nutrient storage.
- We are currently exploring the role of these fungi in resource recycling and their impact on soil structure and stability.
- This research will help us to identify mechanisms to encourage plant establishment on degraded rangelands and to manage rangelands for below-ground associations that promote soil stability and productivity.

Shrub/grass dynamics (Deb Coffin Peters; dcoffin@nmsu.edu)

- Shrub invasion has occurred throughout the Southwest and has been accompanied by major changes in vegetation, soil properties and forage availability.
- We are studying interactions between two grasses (black grama and blue grama; *Bouteloua gracilis*) and creosotebush to understand how these species coexist and compete.
- Relationships of environmental factors (climate, soils and disturbances) with individual plant and population dynamics (recruitment, growth and mortality) are being examined.
- Preliminary indications are that soil seed concentrations and viability differed among the three plant species, timing of water use differed between the two grasses, and depth of water use differed between creosotebush and grasses.
- Disturbance (removing dominant species) altered plant recovery differently depending on species; short-term recovery was most affected by plants remaining on plots for black grama, invading plants for blue grama and plants under the removed shrub canopy for creosotebush dominated plots.
- Moisture use, seed availability and competing species may be involved in shrub invasion.
- Simulation modeling studies showed vegetation and soils were important determinants of recovery of perennial grasses on shrublands: highly degraded soils with low grass cover had slower rates of grass recovery than soils high in organic matter with high grass cover.
- Organic matter inputs from annual plants increased soil

water holding and infiltration capacity, and resulted in faster recovery rates for perennial grasses compared to model analyses without feedback variables.

- Understanding environmental feedbacks on perennial grasses will help us to identify sites most sensitive to grass recovery for use as trigger sites in our remediation work.

- Ultimately, individual plant relationships can be extrapolated to landscape dynamics and help explain events and factors that govern invasion of desert grasslands by shrubs, as well as recovery by perennial grasses in shrub dominated areas.

Fire ecology (Kris Havstad or Deb Coffin Peters; khavstad@nmsu.edu or dcoffin@nmsu.edu)

- The benefits of fire are debated and use of fire as a rangeland improvement tool in deserts has not been thoroughly studied.

- We have started to examine responses of desert ecosystems to fire and the influence of cattle grazing during post-fire recovery on these responses.

- This study will examine the response of black grama and mesquite to fire, and their interactions following fire.

- Measures of plant species cover, composition and richness will be obtained at several spatial scales from small patches to .1 acres to allow us to evaluate the relationships of plant, patch and landscape patterns with responses to fire and grazing.

- This study will allow us to evaluate the role of fire and grazing in shaping landscape patterns, and to determine the management implications of grazing following natural fires.

Disturbances-stressors (Kris Havstad; khavstad@nmsu.edu)

- Disturbances of natural and human origin may drive ecosystem structure.

- Effects of various stresses on vegetation are often similar and difficult to separate (e.g., drought vs overgrazing).

- Though many plant species are present in this environment, the ecological character and functional uses of these rangelands are strongly shaped by only a few species.

- Preliminary indications from a long-term study of rangeland stressors, including drought, soil nutrient depletion and shrub competition suggest stress affects grassland/shrubland ecosystems in several ways; perennial grass cover was decreased most by summer drought, while summer burning of black grama (*Bouteloua eriopoda*) grassland mainly affected annual plants.

- In general, vegetation responses to disturbances, both "natural" and human-caused, result in changes in species abundances rather than pronounced new species additions or losses of species.

- Understanding how specific stresses impact rangeland will lead to approaches to manipulate and improve unhealthy rangeland.

Monitoring and Assessment

Development of indicators and manual (Jeff Herrick; jherrick@nmsu.edu)

- Healthy land requires that soil and water resources be retained and cycled within the landscape.

- Sensitive indicators of ecosystem function have been identified, including size and proportion of bare soil patches, proportion of perennial grasses, a test for soil stability and tests for soil water infiltration rates and soil compaction.

- The measurements used for these general indicators can also be used to calculate other indicators which specifically address the capacity of the land to support livestock production, including proportion of perennial plant species palatable to livestock.

- Soil and plant-based indicators developed here are being tested on sites in other locations in New Mexico and throughout the United States.

- A manual describing a flexible system for establishing a monitoring system will be available within the next year.

- The manual will define a variety of quantitative and qualitative indicators and provide instructions for applying this system to a variety of management objectives in upland, riparian and pinon-juniper areas.

Remediation

Low input/trigger site strategies (Jeff Herrick; jherrick@nmsu.edu)

- Remediation of rangelands resulting in a change in vegetation composition and/or cover is traditionally achieved via chemical or mechanical removal of

existing vegetation followed by seedbed preparation and seeding.

- Water frequently limits seedling establishment and is generally viewed as the most important factor in failure of rangeland seedings.

- Preliminary results from a number of studies indicate natural processes can be altered using relatively limited inputs to facilitate remediation efforts (see following topics).

Runoff (rill and gully) seeders (Jeff Herrick; jherrick@nmsu.edu)

- Using natural runoff to disperse seeds to microsites where more water is available and evaporation is reduced has been accomplished by placing seeders (made from plastic tubing, mesh screen and water-soluble cap) in rills and gullies.

- The force of water releases seeds during storms.

- Survival rate for seeds on the soil surface was equal to that for seeds stored in optimal conditions (a cool, dark room) for an equivalent length of time.

- Preliminary results indicate that most seeds are deposited under litter or in other protected sites where seedlings are protected from dessication.

- Preliminary results from an ongoing study showed seedling establishment in these microsites is greater than in other areas.

Microcatchments (Jeff Herrick; jherrick@nmsu.edu)

- We are evaluating long-term effects of physical barriers designed to produce microcatchments on barren areas by examining low earthen dikes established in 1975 on a barren area (maintenance of dikes was terminated in 1979).

- Plant density, soil characteristics and seed distribution at different distances from these catchments indicated the vegetation, seed and soil resources all increased in concentration as distance to the catchment decreased.

- Results illustrate that dikes constructed several years ago on barren soil resulted in a sustainable improvement; this vegetation continues to slow water movement and increase infiltration time.

- We are now attempting to identify factors which may limit further expansion of these "trigger" sites upslope from the original barriers.

Manure application (Ed Fredrickson; efredric@nmsu.edu)

- Experiments are underway to evaluate nutrient applications to different plant communities. We are using dairy manure as a nutrient treatment in these studies.

- Although it is not considered cost effective to apply to arid rangelands, initial findings are that a single layer of dairy manure (20 tons per acre) before summer rains has several positive effects, including increased plant germination and establishment.

- However, preliminary observations suggest shrub production is increased in treated areas.

- This practice stimulates growth by providing nutrients to an environment that is generally nutrient poor, while providing an alternative means of manure disposal for dairy farmers.

- Application may need to be coordinated with management practices such as shrub control.

Portable shade (Ed Fredrickson; efredric@nmsu.edu)

- A study has been initiated to examine benefits of providing portable shade to cattle.

- Providing shade to livestock in desert environments may improve animal productivity and distribution.

- Concentrated activity (manure and trampling) may have positive effects on plants.

- Cattle crowded below shade structures during midday and the soil surface became bare and heavily manured during each period (7 day replications).

- Long term effects of shade treatments on plant responses will be evaluated.

Livestock Management

Animal behavior-herding and manipulation (Dean Anderson; deanders@nmsu.edu)

- Animal distribution is important for efficient and targeted use of rangelands.

- In spite of the importance of livestock distribution and the amount of research conducted on this subject, uneven use of rangelands remains a problem.

- Many of the practices and principles for improving distribution are based on control rather than capitalizing on innate animal behavior and group

dynamics.

- Past research at this location has focused on forming an association between cattle and sheep that causes sheep to remain with cattle (flerd) and provides predator protection.
- More recent efforts involve use of technology to manipulate the distribution of grazing cattle.
- Individual and group behaviors will be examined in single and mixed-species livestock groups.
- These studies will allow producers to take advantage of current technology to manage herd and flock distribution.

Environmental complexity (Ed Fredrickson; efredric@nmsu.edu)

- The ability of animals to learn may be affected by the degree of complexity of their environment in early life.
- Studies with other animal species suggest that animals reared in more complex environments have greater brain development in regions responsible for memory and learning.
- A study was conducted in which lambs were reared in pens with either slatted or solid panels.
- Slatted panels allowed lambs to see outside their pens, creating a "complex environment". Solid panels prevented lambs from seeing outside their pens, creating a "simple environment".
- Preliminary findings indicate lambs reared in simple environments had difficulty learning new food seeking behaviors and were more stressed in new environments.
- These studies may help us understand how animals learn to use their environment and adapt to changing nutritional environments, and may help explain why animals are more susceptible to poisonous plants in unfamiliar environments.

Diet selection-photography (Ed Fredrickson; efredric@nmsu.edu)

- Research examining diet selection and forage utilization is hindered by techniques that are laborious and inaccurate.
- A rapid and reliable method to determine the amount of browsing on a specific plant would be useful.
- We are developing a technique using digitized photographs (or a digital camera) and readily available image analysis software to accurately measure forage use.
- Alfalfa plants were sampled sequentially and photographs were taken after each sampling.
- Equations were formulated to estimate the amount of material removed from a plant after a bite or browsing interval.
- This technique will improve our ability to accurately assess extent of forage use and could be used in other research.

Diet selection-fluorometry (Dean Anderson; deanders@nmsu.edu)

- Although studied extensively, techniques currently available to monitor diet selection by grazing livestock are tedious and imprecise.
- We have recently begun to examine the utility of fluorometry to improve the accuracy and speed of diet analysis.
- This research is based on the principle that molecules in a sample exposed to an intense light source become excited and emit light as they return to their original state.
- Unique spectral fluorescence signatures from different plant species may provide "fingerprints" for separating plant materials in diets and feces.
- Preliminary research using this technique indicated it could be used to distinguish among fecal samples from sheep consuming simple diets differing in amount of one forage.
- We are continuing to examine spectral differences in plant materials and fecal materials arising from complex diets.
- Also, we are developing equations to separate three dimensional response surfaces from different samples based on spectral characteristics (peak size, shape and location).
- We believe this research will provide technology to assess diets of foraging livestock more accurately and rapidly than is currently possible.

Diet selection-phytochemistry (Rick Estell; restell@nmsu.edu)

- Shrub dominated arid rangelands are widespread, and

many desert shrubs contain chemicals that discourage herbivory.

- When ruminants were forced to eat tarbush, they consumed specific plants and avoided others, and consumption was related to amount of leaf surface compounds.

- When compounds that were negatively related to tarbush consumption were applied individually to pelleted alfalfa, α-pinene and camphor decreased intake by lambs, but limonene, borneol, β-caryophyllene, cis-jasmone, α-humulene, 1,8-cineole, p-cymene, 3-carene and sabinene had no effect.

- Extracts of tarbush (hexane, ether and ethanol) all reduced intake by lambs.

- In an ongoing study, camphene, myrcene, caryophyllene oxide, β-pinene and dilutions of the extracts are being examined.

- Determining which compounds deter herbivory will help establish methods to alter diet selectivity by livestock; potential benefits include additional protein sources and biological control of brush.