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Organization: Duke University

LTER: The Chihuahuan Desert (The Jornada LTER III Consortium)

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Worked for more than 160 Hours: Yes
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New Mexico State University

Agricultural Research Service
The Jornada Experimental Range is operated by the Agricultural Research Service and available for use by LTER investigators

Chihuahuan Desert Rangeland Research Cen
The Chihuahuan Desert Rangeland Research Center manages lands owned by New Mexico State University in the Jornada Basin. Many of the LTER studies and intensive study sites are found on CDRRC lands.

Other Collaborators

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Activities and Findings

Research Activities:
Over the past 10 years, we have developed a long-term monitoring program and archival datasets in each of these areas, to provide a baseline of information regarding the response of the Chihuahuan Desert ecosystem to climatic fluctuations and to regional changes in climate. Research on disturbance is of particular interest: Any insight gained on the role of cattle as a disturbance agent would surely aid the ongoing national effort to reevaluate the impact of grazing on public lands throughout the southwestern United States. In addition, development of remediation technologies for degraded landscapes requires a thorough understanding of the processes associated with disturbance (Herrick et al. l997).

Beyond our studies of the causes of desertification in southern New Mexico, we are also interested in its regional effects. Using the Jornada as an example, we have postulated the role of deserts in determining regional to global characteristics of the Earth's climate and biogeochemistry (Schlesinger et al. l990). Loss of vegetation raises regional albedo, but also, regional air temperatures (Bryant et al. l990). Barren soils are a source of wind-borne dust, which can affect the radiative balance of the planet depending on the mineralogy of dust and its persistence in the atmosphere (Tegen and Fung l995, Sokolik and Toon l996). Loss of vegetation lowers the infiltration of soil moisture, leading to higher runoff losses of rainwater, greater losses of soil nutrients, and the persistence of regional desertification (Abrahams et al. l995, Schlesinger et al. 1999). Thus, the LTER studies in the Jornada Basin treat both the cause and effect relationships associated with the shrub invasion of semiarid grassland habitats.

The Jornada Basin in the Chihuahuan Desert.

The Chihuahuan Desert is the largest desert in North America. The vast majority of this desert occurs in Mexico, in the States of Chihuahua and Coahuila. The habitats of the Jornada del Muerto Basin are most representative of the northern Chihuahuan desert (the Trans-Pecos region) and of the sensitive transition between the short-grass prairie of the central U.S., and the shrub-dominated ecosystems of the Sonoran and Mojave Deserts to the west of the Continental Divide.

The Jornada Basin receives an average of 23 cm/yr of precipitation--about half in monsoonal storms that derive from the Gulf of Mexico during the late summer and the remainder in synoptic weather systems stemming from the Pacific Ocean during the winter months. Rainfall shows large interannual variability that controls the relative growth of C-3 shrubs during the winter and C-4 grasses in summer. Potential evapotranspiration is about 230 cm/yr, so the Bowen ratio--the dissipation of sensible versus latent heat--is very high. During the summer, the mean maximum temperature is 36 C, and often little or no precipitation is recorded in the months of May and June.

The Jornada Basin is typical of the closed-basin topography that is found in many arid regions of the southwestern United States. Parallel, north-south block-faulted mountains separate individual valleys, which have a predominance of internal drainageways terminating in intermittently flooded lakes, known as playas. In the Jornada basin, soils are largely derived from alluvial deposits from the mountains, as well as from floodplain deposits laid down by an ancient water course of the Rio Grande through the Jornada del Muerto valley. The entire surface is subject to wind erosion and eolian redistribution of soil materials.

When we began our work, existing studies of plant growth showed little difference in the net primary production (NPP) between black grama grasslands and the various shrubland habitats of the Jornada basin. Rather, plant production seemed determined by landscape position--with greater plant growth in areas where runoff water accumulated and lower plant production in areas of limited soil moisture (Noy-Meir 1985, Ludwig 1986). The similarity of NPP between grassland and shrubland habitats suggested that plant production, per se, was not a good index of desertification, to the extent that this term is appropriate to the historical loss of productive semiarid grassland in southern New Mexico.

As an alternative, our research group has focused on changes in the distribution of essential soil resources during the transition from grassland to shrubland habitats. Sampling shrublands at a scale of 10- to 100-cm intervals, we found enormous variation in the content of nitrogen among soil samples. When we sampled grasslands at the same spatial scale, the soil samples seemed rather homogeneous in basic soil characteristics (Schlesinger et al. l990, l996). Of course, ecologists have long-recognized that patches, or 'islands,' of fertility gather under shrub vegetation, which leads to a heterogeneous distribution of soil resources in deserts. What was new to our work was that we hypothesized that the desertification of semiarid grasslands may not be so much associated with a change in vegetation production as with an increase in the spatial heterogeneity of soil resources. The heterogeneity of soil resources created by invading shrubs is followed by a further localization of soil resources under shrub canopies promoting the invasion and persistence of shrubs. The patchy distribution of soil resources leads to heterogeneity in the distribution of soil microbial biomass (Herman et al. 1995), nematodes (Freckman and Mankau 1986), and microarthropods (Santos et al. 1978). The patches of soil fertility created by plants and animals are preferred sites for the establishment of shrubs (Chew and Whitford l992, Silvertown and Wilson l994). Barren areas between shrubs are increasingly subject to the physical removal of soil resources by water and wind erosion, and the potential for long-term depletion or loss of soil nutrients.

Desertification.

Drought is certainly linked to the downfall of great historic civilizations, including the early Mesopotamian civilization in 2200 B.C. and the Mayan culture in Mexico around 900 A.D. In the future, we can expect that the position of the border between arid and semiarid lands will be one of the most sensitive indices of global climate change, which may include a transient period of widespread drought during the next century (Rind et al. l990).

Throughout the world, lands at the border of arid regions are increasingly subject to human impact, leading to degradation of soils, losses of plant production, and a diminished economic potential to support human populations. Focusing on the human impact and consequent losses in economic potential, we often call these changes 'desertification' (Dregne et al. l99l). With the potential for global climate change, however, the definition of desertification and its potential must be expanded. Indeed, the 1992 United Nations Desertification Convention defined desertification as 'land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities.'

Even this definition will be problematic. Desertification should not be used to describe cyclic phenomena, as when decadal variations of precipitation lead to periods of drought and to losses of vegetation cover that are fully restored when the rains return. Indeed, Tucker et al. (l994) showed that most of the southward expansion of the Sahara desert in the early l980s was effectively reversed with a return to a period of greater rainfall later in that decade. Schlesinger and Gramenopoulos (l996) found no evidence of a long-term decline in woody vegetation, from 1943 to 1994, in areas of the western Sudan, removed from human activities.

The Chihuahuan Desert dates to about 9,000 years ago. It has been hypothesized that during the last 3,000 years there have been three transitions between grasslands and shrublands, each followed by a return of grasslands in southern New Mexico (Van Devender l995).

Today, perennial bunchgrasses, such as black grama, may represent a relictual community from more mesic climatic conditions in the mid-Holocene. Some modern plant species endemic to the desert were certainly present when large herbivores, such as ground sloths and mammoths grazed the Chihuahuan desert, but apparently this region has not been subject to high levels of herbivory by bison and other native ungulates for the past 10,000 years (Mack and Thompson l982, Bock and Bock l993).

We believe that the recent changes in ecosystem structure and function in southern New Mexico may represent a desertification process that is driven by human impact. When subjected to high levels of cattle grazing in the late 1800s, the grassland ecosystems appear to have shifted to an alternate stable-state, in which shrub vegetation is dominant (Laycock l99l). The shift is likely to have been aided by a decline in the proportion of summer precipitation, which favors the C-4 perennial grasses, in favor of winter precipitation, which favors shrubs (Neilson l986). This shift may reflect an increasing frequency of Pacific El Nino events, which enhance wintertime synoptic rainfall in the southwestern U.S (Redmond and Koch l99l, Molles and Dahm l990). Certainly, fire suppression, which aids the establishment of shrub seedlings (Humphrey 1958), and rising CO_2, which benefits the photosynthesis of C-3 shrubs (Idso 1992; but see also, Archer et al. l995), may have aided the transition from grassland to shrubland.

We consider all of these factors as allogenic--acting from outside the ecosystem to cause changes in the structure and function of the Chihuahuan desert. The allogenic factors are reinforced by autogenic factors, including the development of soil heterogeneity and islands of fertility, which act internally to reinforce the invasion and persistence of shrubs in the ecosystem (Reynolds et al. l997).

Socio-economic Factors in Future Environments.

High rates of human population growth, low per capita income, and land-use changes driven by an increasing globalization of the world's economy will impact natural ecosystems in most semiarid environments throughout the world. Nowhere is this better seen than in the nightly news from Sahelian Africa, but similar socioeconomic factors have the potential to cause dramatic changes in the ecosystems of the Chihuahuan desert. In southern New Mexico, for example, the population of Do±a Ana county will haven grown by nearly 40% in the decade of the l990s (Peach and Williams, l997). Similar, high rates of population growth are found throughout much of the Chihuahuan desert of Mexico.

In addition to the direct space needed for human occupancy, the infrastructure needed to support this population will have widespread impacts on desert ecosystems, which will be increasingly traversed by roads, powerlines, and aqueducts. In construction activity, humans leave barren soils subject to wind erosion, reroute and linearize natural drainageways, and replace native arid-land vegetation with more profligate users of water. These desert areas will be battlegrounds in a conflict to increase economic production to support a growing human population in a region of sparse and unpredictable resources.

Although socioeconomic studies have not been the explicit focus of most LTER programs, increasingly we see our studies expanding to include comparisons of human impact in the cross-border region of U.S. and Mexico. Within this region, it is increasingly important that we develop the knowledge and technologies for mitigating the impacts to desert environments and for improving environmental conditions for the increasing human population that lives there. An understanding of basic processes of desert ecosystems must form the basis of management and remediation techniques. Predicting how the natural ecosystems of southern New Mexico will respond to human impacts is a critical goal for our future research.

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Whitford, W.G., A.G. de Soyza, J.W. Van Zee, J.E. Herrick and K.M. HAVSTAD. l998. Vegetation, soil, and animal indicators of rangeland health. Environmental Monitoring and Assessment 51: 179-200.

Whitford, W.G. and H.M. Sobhy. 1999. Effects of repeated drought on soil microarthropod communities in the northern Chihuahuan Desert. Biology and Fertility of Soils 28: 121-128.

Research Findings:

Research Findings, specific to 1998-1999:

Core Area 1: Net Primary Productivity

Net primary production data extending from spring 1989 to fall 1998 confirmed that the spatial heterogeneity of aboveground plant biomass at the scale of our measurements is significantly greater in shrub-dominated systems than in grass-dominated vegetation. Net primary productivity per square meter was rather homogeneous across space in grass-dominated systems, but in some seasons was significantly more heterogeneous (patchy) in shrub vegetation. Overall mean values of biomass and of net primary productivity did not vary among ecosystem types, suggesting that desertification or vegetation conversion in this region has not been accompanied thus far by any decrease in the average value of productivity. Temporal patterns in net primary production were examined using data from spring 1989 - fall 1998, a period that encompassed both unusually wet and unusually dry intervals. While some sites showed similar temporal patterns (e.g., NPP patterns were highly correlated at all 3 sites dominated by Larrea), the overall tendency was for NPP to be uncorrelated among different vegetation types, and among different sites within a vegetation type. That is, highly productive seasons for some sites were not necessarily productive for all sites. Although our ability to detect differences among ecosystem types is limited, there was some tendency for grassland to show higher interannual variation than did sites dominated by shrubs, consistent with the hypothesis that shallowly rooted grasses would be highly sensitive to weather patterns. Grassland productivity is dominated by plant growth in fall, while sites dominated by Larrea and by Prosopis tended to have higher spring production than fall. This pattern suggests that changes in the composition and structure of vegetation with desertification have also altered the phenology and seasonal availability of plant matter in these systems.

Core Area 2: Trophic Relations:

Rodent populations at the Jornada declined from fall of 1998 through spring of 1999, while rabbit and arthropod densities remained relatively constant. Lizard densities increased in fall of 1998, but declined in spring of 1999. Rodent populations are exhibiting fluctuations that correspond to rainfall and plant production. Arthropods and lizards also showed some response to rainfall and plant production, but patterns were not as clear as those for rodents.

Data from the Small Mammal Exclosure Study (SMES)--which is an intersite comparison between the Jornada, the Sevilleta and the Mapimi sites-- have revealed that plant canopy cover has increased significantly on the rodent and rabbit exclosures compared to the control plots over the past three years. Some plant species in particular have increased dramatically on the rodent and rabbit exclosure plots. Colonies of seed harvester ants have also increased significantly on the rodent and rabbit exclosure plots at the creosotebush site, but not at the grassland site, nor at Sevilleta or Mapimi. The increase in seed harvester ants at the creosotebush site appears to be in response to increased canopy cover and seed production of one species of perennial grass. The grass is grazed by rodents and rabbits outside of the exclosures, reducing seed production. In contrast, at the grassland site, reduced soil disturbance by rodents and rabbits on the exclosure plots corresponds with a decline of annual plants, and seed harvester ants.

These results demonstrate that rodents and rabbits have significant impacts on plants and other consumers, but differ between shrubland and grassland environments, and among sites across the Chihuahuan Desert. Of even greater significance are the indications that herbivory and soil disturbance by rodents and rabbits, not granivory, appear to be the principal mechanisms accounting for interactions with plants and granivorous ants.

Core Area 3: Biogeochemical Pools

As part of the LIDET intersite decomposition study, we compared mass loss patterns, bulk chemistry and isotope values (d13C, 15N) of buried root litter collected annually for five years. Our objective is to learn about relationships between long-term decomposition and isotopic discrimination in plant litter characteristic of aridlands. We hypothesized that patterns of N immobilization and mineralization control changes in the 15N abundance of plant litter, while changes in litter 13C are related to changes in lignin.

Fine roots of Drypetes glauca (tropical hardwood), Pinus eliottoi (conifer) Schazachyrium gerardi (grass) and wooden dowels of Gonystlyus bacannus (tropical hardwood) were buried and then collected annually for 5 years. We did not see a relationship between litter N dynamics and C/N ratios, even though mass loss followed predictable patterns (after 5 years mass loss by species varied from 69% to 22% of initial). Average 15N values of buried roots and the wood increased about 2 per mil. These increases were independent of litter N content and may reflect microbial fractionation or retention of 15N enriched substrates. Previous LTER intersite work has identified desert and grassland soils as being 'heavy' (higher 15N) compared to more mesic sites. The reasons behind this observation remain unclear, but suggest fundamental intersite differences in N cycling processes.

The d13C of decomposing litter was less variable than 15N. Schazachyrium gerardi was the most dynamic and decreased by about 2 d13C during the first two years and then increased slightly. Based on isotope signals, we did not see an import of exogenous C from soil (d13C ~ -22) into the litter materials. The lack of a clear relationship between lignin and C/N with isotope ratio suggests that the controls on buried litter decomposition in arid ecosystems may differ from most other systems. Our results show that isotopic fractionation of C and N is most characteristic of early litter decay stages and may highlight aspects of nutrient cycling processes that are unique to aridlands.

Core Area 4: Biogeochemical Flux

Losses of dissolved nutrients (N, P, K, Ca, Mg, Na, Cl, and SO4) in the runoff from natural storms were measured on grassland and shrubland plots in the Jornada Basin. Runoff began at a lower threshold of rainfall in shrublands than in grasslands, and the runoff coefficient averaged 19.7% on shrubland plots over a 7-year period. In contrast, grassland plots lost 5.3 to 6.0% of incident precipitation in runoff during a 6-year period. Nutrient losses from shrubland plots were greater than from grassland plots, with nitrogen losses averaging 0.33 kg ha-1 yr-1 vs. 0.15 kg ha-1 yr-1, respectively, during a 3-year period. The greater nutrient losses in shrublands were due to higher runoff, rather than higher nutrient concentrations in runoff. In spite of these nutrient losses in runoff, all plots showed net accumulations of most elements due to inputs from atmospheric deposition. Therefore, loss of soil nutrients by hillslope runoff cannot, by itself, account for the depletion of soil fertility associated with desertification in the Chihuahuan desert.

We checked these conclusions by performing rainfall simulation experiments on grassland and shrubland plots. The objective was to compare the runoff of nitrogen (N) and phosphorus (P) from these habitats to assess whether losses of soil nutrients are associated with the invasion of grasslands by shrubs. Weighted average concentrations of total dissolved N compounds in runoff were greatest in the grassland (1.72 mg/l) and lowest in bare plots in the shrubland (0.55 mg/l). More than half of the N transported in runoff was carried in dissolved organic compounds. In grassland and shrub plots, the total N loss was highly correlated to the total volume of discharge. We estimate that the total annual loss of N in runoff is 0.25 kg/ha/yr in grasslands and 0.43 kg/ha/yr in shrublands-- consistent with the depletion of soil N during desertification of these habitats.

Core Area 5: Disturbance:

Ecosystem boundaries and geographic distributions of species are predicted to change in response to directional changes in climate, but the ability of plants to shift their geographic distribution depends upon processes associated with recruitment, growth, and mortality. Because these processes are nonlinearly related to climate and are also affected by soil processes, lag times in responses may result. Recent climate change simulation analyses predict an expansion of Chihuahuan desert grasslands and a reduction of shrublands in the southwestern U.S. During the past year, we began a research program to relate plant life history traits and soil development processes to responses of important species in these ecosystems. We are using a spatially-interactive gap dynamics model to predict responses for three conditions of initial soil development--from soils that are rich in organic matter to highly degraded soils. Predicted response times range from decades to millennia, with more rapid responses on well developed soils. Plant life history traits are an important constraint on soils with high organic matter content. Although directional climate change may shift species distributions, these shifts will not occur rapidly or uniformly across a landscape or region, and will depend upon interactions between plant and soil processes.

The effects of different types of soil surface disturbance, including those caused by horses and off-road vehicles, are being evaluated on five different soil types. The two sites at the Jornada are located in tarbush (Flourensia cernua) and creosote (Larrea tridentata) communities. Three additional sites in the adjoining Tularosa Basin are located on gypsic soils. All treatments were completed under dry conditions. Post-disturbance and one-year post-disturbance differences have been analyzed for the three soils at the gypsic site, and preliminary analyses have also been completed for the two Jornada sites. These analyses support the hypothesis that relatively fine-textured upland soils tend to be more resistant to disturbance than coarser-textured soils. Two-thirds of the variables measured significantly affected disturbance the dune margin site, while fewer than 25% were statistically significant at the gypsum-silica transition site. A surprising conclusion, however, is that areas of gypsum outcrop can be quite resistant and support a relatively high vegetative cover. Both the outcrop and gypsum-silica transition sites would appear to be more resistant to disturbance than the highly gypsiferous dune margin areas. Further studies will indicate how rapidly these various sites may recover in response to disturbance.

Research Training:

A large number of students, ranging from undergraduates to doctoral candidates have been involved in research at the Jornada. Many of the undergraduate students have been supported by the NSF program-Research Experience for Undergraduates (REU), with supplemental funds from NSF. The list below shows those students associated with the Jornada since October 15, 1994-the beginning of the current grant. We have divided this list into two sections to show those who have completed their degree and those that are currently actively in the pursuit of a degree at one of the participating institutions. In the pursuit of their degree, each of these students develops skills in field ecology, in data collection and analysis, and in oral and written presentations of their work. Several years ago, we performed a 'follow-up' study to ascertain the career pathways chosen by REU students trained at the Jornada. This was published in the Spring 1997 issue of our newsletter 'Jornada Trails,' Volume 3, issue #1, which is available on our website: http://jornada.nmsu.edu.

STUDENTS

Students Trained as part of the Jornada LTER-III

15 October 1994 -- present

Completed Degree Requirements:

Graduate:

Tiszler, J. l994. Changes in soil nitrogen dynamics with the establishment of desert shrubs in a Chihuahuan black grama grassland. M.S. Thesis, San Diego State University (R.A. Virginia, advisor).

Brisson, J. 1994. Growth plasticity and neighborhood interactions with special reference to creosotebush (Larrea tridentata). Ph.D. Dissertation, San Diego State University (J.F. Reynolds, advisor)

Horton, J.D. l995. Using kriging to predict distribution of arid vegetation, with discussion of cokriging field data and satellite imagery. Ph.D. Dissertation, New Mexico State University (K.M. Havstad, advisor).

Thompson, J.B. l995. Regeneration niches and nurse plant associations in Chihuahuan desert perennials. M.S. Thesis, New Mexico State University (L.F. Huenneke, advisor).

Marlies, E.H. l995. Application of stable carbon and nitrogen
isotopic signatures as tracers of vegetation changes accompanying desertification. M.S. Thesis, Dartmouth College (Ross A. Virginia, advisor).

Encina-Rojas, A.E. l995. Detailed soil survey of the Jornada LTER (Long-term Ecological Research) Transect vicinity, southern New Mexico. M.S. Thesis, New Mexico State University (H. Curtis Monger, advisor).

Buck, Brenda. 1996. Late Quaternary landscape evolution, paleoclimate, and geoarchaeology, southern New Mexico and west Texas. Ph.D. Dissertation, New Mexico State University (H. Curtis Monger, advisor).

Pan, J.J. 1996. The effects of grazing history, plant size, and plant density on growth and production of black grama grass (Bouteloua eriopoda). M.S. Thesis, New Mexico State University (M. Cain, advisor).

Li, Gang. l996. Sediment transport capacity of laminar overland flow. Ph.D. Dissertation, State University of New York, Buffalo (A. Abrahams, advisor).

Connin, Sean L. 1996. Variations in the isotopic composition of pedogenic carbonate: contributions of vegetation, soil disturbance and diagenesis. Ph.D. Dissertation, Dartmouth College (R.A. Virginia, advisor).

Lassetter, W.L. Jr. l996. Changes in soil labile-C indicated by the ratio of microbial biomass-C to total organic-C in a semiarid grassland undergoing desertification. Ph.D. Dissertation, University of Nevada, Reno (R.A. Wharton, Jr., advisor).

Hartley, A.E. l997. Environmental controls on nitrogen cycling in northern Chihuahuan desert soils. Ph.D. Dissertation, Duke University (W.H. Schlesinger, advisor).

Baggs, J. l997. Effects of black grama (Bouteloua eriopoda) on community and ecosystem properties in Chihuahuan desert grassland. M.S. Thesis, New Mexico State University (L.F. Huenneke, advisor)

Montes-Helu, M.C. 1997. Track-vehicle disturbance on rangeland and design of sapflow gage for desert shrubs. Ph.D. Dissertation, New Mexico State University (Tim Jones, advisor)

Herrera-Matos, J. 1998. The biodiversity of nitrogen-efficient guild bacteria in Chihuahuan Desert soils at the Jornada Basin LTER site, New Mexico. M.S. Thesis, New Mexico State University (R.P. Herman, advisor).

Ziesset, M. 1998. Effect of plant community structure on insect community structure in the Chihuahuan Desert. M.S. Thesis, New Mexico State University (L.F. Huenneke, advisor)

Kipp, J.M. 1998. Quaternary pedogeomorphology, paleoclimate, and geoarchaeology along the Pyramid Mountains Piedmont, southwestern New Mexico. (Ph.D. Dissertation, New Mexico State University (H.C. Monger, advisor)

Howes, D.A. 1999. Modeling runoff in a desert shrubland ecosystem, Jornada Basin, New Mexico. Ph.D. Dissertation, State University of New York at Buffalo (A.D. Abrahams, advisor).

Neave, M. 1999. Impact of small mammal disturbances on water and sediment yields in the Jornada Basin, southern New Mexico. Ph.D. Dissertation, State University of New York at Buffalo (A.D. Abrahams, advisor).

Gallegos, R. 1999. Biogenic carbonate, desert shrubs, and stable isotopes (M.S. Thesis, New Mexico State University (H.C. Monger, advisor).

Martinez-Rios, J. 1999 The use of LANDSAT in making soil maps of the Mapimi Biosphere Reserve, Mexico. Ph.D. Dissertation, New Mexico State University (H.C. Monger, advisor)

Undergraduate:

Ambro, Sharon. 1998. B.A., Marietta College, Marietta, Ohio (1997 REU Student at the Jornada)

Amweg, Erin. 1998. B.S. Duke University. (1997 REU student at the Jornada).

Bogner, Heidi. 1998. B.S. University of Guelph (1997 REU student at the Jornada).

Bortz, Heavin. 1996. B.S. Duke University (1996 REU student at the Jornada).

Carlisle, LaDonna. l997. B.S. New Mexico State University (l996 REU student at the Jornada)

Charlton, Matthew. 1997. B.Sc. King's College London

Core, Lisa. 1998 A.B. Dartmouth College (1997 REU Student at Jornada)

Garcia, Antoni. 1995. B.S. New Mexico State University (1994 REU student at Jornada).

Gladdin, Paul. l998. B.S. New Mexico State University.

Galos, Patricia. B.S. New Mexico State University (1996 REU Student at the Jornada)

Gross, Kevin. l996. A.B. Duke University (1995 REU student at Jornada).

Gurrola, Javier. 1995. B.S. New Mexico State University (1994
REU student at Jornada)

Lacey, Colleen. l996. B.S. New Mexico State University (1994 REU student at Jornada)

Langely, Adam. l998. B.S. New Mexico State University (l997 REU student at Jornada)

Love, Nicole. l997. B.A. State University of New York at Buffalo (l997 REU student at the Jornada)

McCabe, S. l995. B.A. State University of New York at Buffalo (l995 student at the Jornada).

Middleton, Barry. l995. B.S. New Mexico State University (1994 REU student at the Jornada).

Mooney, J. 1997. A.B. Dartmouth College (1995 REU Student at Jornada)

Najera, Felicia. l998. B.S. New Mexico State University. (1994 REU Student at the Jornada)

Provencio, Kerri. l997. B.A. George Mason University (1994 REU student at the Jornada)

Rayburg, Scott. 1996. B.A. State University of New York at Buffalo (1996 REU student at Jornada).

Robison, Rondi. 1997. B.S. New Mexico State University

Rucker, Amber. 1998. B.S. Southwestern College, Kansas (1997 REU student at the Jornada).

Wright, Allison. l997. B.S. Eastern Michigan State University (1994 REU student at the Jornada).

In Progress:

Alexander, Anthony. M.S. Program, New Mexico State University (R.P. Herman, advisor)

Bauer, Sarah. A.B. Program, Duke University (l998 REU student, J.F. Reynolds, advisor).

Bothern, Lawrence. B.S. Program, New Mexico State University (1999 REU student at the Jornada, L.F. Huenneke and Dale A. Gillette, advisors)

Carson, K. B.S. Program, New Mexico State University.

Collier, S. M.S. Program, New Mexico State University (R.P. Herman, advisor)

Fernandez, R. Ph.D. Program, Duke University (J.F. Reynolds, advisor).

Granados, A. Ph.D. Program, New Mexico State University (H.C. Monger, advisor)

Inzunza-Ibarra, Marco. M.S. Program, New Mexico State University (H.C. Monger, advisor)

Jones, S. B.S. Program, New Mexico State University (R.P. Herman, advisor).

Locklear, Adrienne. B.A. Program, New Mexico State University-Alamogordo. (l998 REU Student, J.E. Herrick, advisor)

Michaud, Gordon. M.S. Program. New Mexico State University (H.C. Monger, advisor)

Mortensen, E., M.S. Program. New Mexico State University (V.P. Gutschick, advisor).

Ogle, Kiona, Ph.D. Program, Duke University (J.F. Reynolds, advisor)

Pilmanis, A. Ph.D. Program, Duke University. (W.H. Schlesinger, advisor).

Sanders, M. B.S. Program, New Mexico State University

Stano, Lisa. B.S. Program, Duke University (1999 REU Student at the Jornada)

Sullivan, T. B.S. Program, New Mexico State University

Wang, Jason. Ph.D. Program, King's College, London (N. Drake and J. Wainwright, co-advisors).

Education and Outreach:
Articles in the popular press, television interviews, and other public media that interpret Jornada LTER research for a general audience.

October l5, l994 -- present

Publications:

'Science at Home on the Range,' November l994 article in Agricultural Research, a monthly magazine published by the by the U.S.Department of Agriculture for farmers and ranchers.

'Watching Desert Creep,' December l994 article in Dialogue, a weekly newspaper published for the Duke University community.

'Students Study Growth in NM,' December, l2, l994 article in The El Paso Times.

'How to Make a Desert,' February l995 article in Discover, a national monthly science magazine published by The Walt Disney Company.

'Success Secrets of Desert Plants,'   March l995 article in Agricultural Research (see above).

'Desert Holds Keys to Land, People who live on land,' October 19, 1995 article in the Las Cruces Sun Times.

'Paleo-Forecast: Ice Age Under High Pressure.' Summer l997 article in New Mexico Resources, a quarterly magazine published by the New Mexico State University College of Agriculture and Home Economics.

'Grassland Prototype Validation Exercise (PROVE) at Jornada Experimental Range.' July/August l997 article in The Earth Observer, (Vol. 9, pp. 16-18), published by NASA.

'Deconstructing the Desert: Scrubland Patrol' March/April l998 article in Duke Magazine, (Vol. 94, n.3, p. 41-43), published by Duke University for its alumni and friends.

'Portugal now getting less rain then [sic] in earlier decades.' April 2, l998 article in Anglo-Portuguese News p. l8

'Desert Lands: Vast, wild and wondrous.' June l998 article in Aggie Panorama (Vol. 47, n. 1. pp.6-7), published quarterly by New Mexico State University for its alumni.

'Air gets worse with every move,' February 21, 1999 article in the El Paso Times.

'Traveling workshop planned for Border Book Festival,' February 28, 1999 article in the Las Cruces Sun News, describing a field trip to the Jornada Experimental Range to accompany the Festival.

'The Desertification Convention: New Mexico Stands to Benefit,' Letter to the editor, March 7, 1999, Las Cruces Sun News

'Girls Can! Sixth-graders expand horizons at career awareness conference,' March 15, 1999 article in the Las Cruces Sun News,

Presentations

Laura Huenneke spoke on 'Ecological Impacts of Grazing in Semi-arid Rangelands' -- the first of four lectures in a symposium on public land grazing in the Southwest,'What's the Beef?' held at the Southwest Environmental Center, Las Cruces, NM, October l996.

Kris Havstad briefed the staff of the Smithsonian Natural History Museum in support of their development of a new exhibit entitled 'Forces of Change,' and he described the value of the long-term datasets gathered at the Jornada. February 1997.

The Jornada Basin LTER presented a booth at the annual Earth Day celebration in Las Cruces, May 1999

Workshops

'Ecologically Sensitive Ranching,' organized by Kris Havstad and Jim Winder,   Santa Fe, New Mexico, June l997,
Silver City, New Mexico, February l998
Roswell, New Mexico, July l998

Video

'Evolution of the Rio Grande Valley,' a 30-minute video prepared for distribution to high school and early college students describing the recent geomorphological history of the Jornada Basin.

Other Outreach

The Jornada Basin Focus group. During the past year, the Jornada Basin LTER researchers met twice as part of a focus group composed of individuals representing state, federal and non-profit environmental, animal production, and rangeland resource organizations. The committee discussed current and future research activities at the Jornada, relative to local issues of concern.

Consultations. Several LTER researchers were asked by local, state and federal officials to provide input on wind erosion problems in southern New Mexico. LTER personnel continue to provide advice on endangered species and on exotic species invasions. The ARS's monitoring program, which relies on LTER research to support indicator selection and interpretation, is being tested and implemented throughout the western United States and northern Mexico by a variety of state, federal and non-profit organizations.

Journal Publications

Books or Other One-time Publications

Web/Internet Sites

URL(s):
http://jornada.nmsu.edu
Description:
This website contains general information about the Jornada Basin LTER, a catalog of long-term datasets, which allows access to data and metadata, access to a variety of spatially-explicit (Geographic Information System) databases, newsletters and other information about long-term ecological research in the Jornada Basin. For a description of recent improvements to our information (data) management systems, see Fastlane Webpage on "Products"

Other Specific Products

Product Type: Data or databases
Product Description:
We maintain an archive of data from our long-term studies at the Jornada--focusing on the core areas of research (See Research Activities). This database is indexed and accessible from our website.

Sharing Information:
Information Management System (IMS)

The Jornada LTER has begun building a relational database management system using Visual FoxPro and other components of Visual Studio. The IMS will be a combination of a 3-tier web application (Internet) and client-server application (Intranet). Data set availability on the Web continues to be expanded. The number of visitors to the Jornada LTER web site has increased from 2350 to 3360 in the past year. The pages showing the greatest number of hits continue to be species lists for the Jornada Basin as well as climate and soil water data. Visiting researchers for the year included REU students as well as graduate students, both local and national.

The 1998 LTER Site Supplement has allowed the Jornada LTER to update site office computers, servers, and software applications in support of an expanded IMS. A new web server has been purchased and will be implemented within the next few weeks in conjunction with ESRI Internet Map Server. A new laptop computer was also purchased and the LAN cabling upgraded. Extended support for a GIS assistant has resulted in digitization and development of numerous projects that were backlogged.

Geographic Information Systems (GIS)
Tasks accomplished this year include digitization of the new (1998) USDA Jornada Experimental Range (JER) and the NMSU Chihuahuan Desert Rangeland Research Center vegetation maps and building related databases, digitization of the historic (1858, 1915, 1923) vegetation maps, collection of existing metadata for the Digital Elevation Models covering the Jornada Basin, and miscellaneous smaller mapping projects. The vegetation maps in particular are crucial both as general context for any new or ongoing studies, and as the essential foundation for our current emphasis on linking vegetation change with geomorphological and soil features.

LAN Improvements
The Jornada LTER LAN was converted from thin net (Coax) to Universal Twisted Pair (UTP). This has dramatically improved network performance. Migrating to UTP also allows the LAN to be segmented and tuned for optimal performance.

File Server
A RAID controller and hard drive were added to the Compaq ProLiant 1500 file server to allow the use of RAID level 5. This has resulted in higher data read/write throughput to the hard drives and a higher level of protection from hard drive failures. The operating system on the file server was upgraded to NetWare 5. Novell's ZENworks and ManageWise server software applications were added to the file server to facilitate remote software and hardware configuration, monitoring, and updating from one central LAN workstation. The backup software has been upgraded in order to run on the new operating system using the old 8-mm tape library. A new tape drive was purchased for the tape library to reduce network backup times. A dual 10/100 Mb network card was installed to improve network performance.

Web Server
A new Gateway ALR-7200 server was purchased to act as our new web/application server. The server has dual PII-350 processors with 256 Mb of RAM and storage capacity of 18 Gb. A dual 10/100 Mb network card was installed to improve network performance for the web/application server.

GIS Computer
A new Gateway E-4200 computer was purchased to replace an older GIS computer that will be used as an Internet Map Server to provide spatial data and associated metadata over the Web. The computer has a PII-400 processor with 128 Mb of RAM and 19 Gb of capacity (9 Gb from the old GIS PC). The old 8-mm tape drive from the tape library was installed to allow transferring large datasets from 100Mb to 14 Gb in size. A CD Rewriter was acquired to allow for archiving datasets and images (up to 640 Mb) on CD media. These improvements allow the GIS/Remote Sensing person, Barbara Nolen, to work with larger datasets much more easily and with greater efficiency.

Site Office Computers
Two Gateway E-4200 computers were purchased to replace older P-90 computers. Each computer has a PII-400 processor with 128 Mb of RAM and 10 Gb of capacity. These are used to manage datasets/metadata and for application development related to the IMS. Additionally, a Winbook laptop computer as purchased for use as a field and travel computer in support of research and administrative functions. It is a PII-266 with 64 Mb of RAM and 2.1 Gb in storage capacity.

Year 2000 Compliance Testing
All mission critical Jornada LTER computers (servers and workstations) have been tested and are hardware Year 2000 compliance. A site software inventory is underway to determine Year 2000 compliance and the need to upgrade to a compliant version. All data and metadata are archived in flat ASCII format; Year 2000 concerns are not applicable.

Contributions

Contributions within Discipline:
Field data from the Jornada Basin LTER provide ground truth and validation for the development of satellite remote sensing on NASA's EOS Platforms. In addition, Jornada field sites have been used to examine issues of extrapolation from small-scale field studies to coarse-scale remote sensing activities, through NASA's PROVE campaign. Field studies in the latter are highlighted in the NASA publication, Earth Observer, Volume 9, pp. 16-19, July/August 1997.
Contributions to Other Disciplines:

Contributions to Education and Human Resources:
K-12 Educational Activities

LTER scientists, in collaboration with the ARS and the non-profit Chihuahuan Desert Nature Park (CDNP), enhanced K-12 education through four types of activities: field trips to the Jornada, classroom visits, establishment of schoolyard LTER sites, and teacher training.

Field trips. We hosted over 1000 children on one-day field trips to the Jornada. The schools represented six different school districts in southern New Mexico and west Texas. Student groups of 30 to 130 students are divided into 3 or more groups and rotated among several stations showing our studies of rumen ecology, weather and climate, invertebrate and vertebrate ecology, and soils. The stations available depend on teacher preferences and staff availability. The stations are all hands-on and some include measurements and discussion of statistics (depending on age). Demand exceeded our ability to respond to all requests.

Classroom presentations. We also provided in-school presentations to over 2,000 students. These presentations generally focus on natural history, but often also include discussions of interactions between humans and our environment. Again, demand exceeded our ability to respond to all requests.

Schoolyard LTER. During the 1998-99 school year, we established Schoolyard LTER sites at an elementary school in Las Cruces and a high school in El Paso. We initiated development of standard protocols for establishment of these sites and incorporated site development and teacher training into our First Step program. One middle school in Las Cruces has been selected for a new site in 1999/2000, and three additional middle schools (one in Las Cruces and two in the El Paso area) have asked to be included even without support.

College-level and Graduate Education:
For Information on College-level and Post-graduate Educational Activities see the FASTLANE WEBPAGE (with this report) on 'Training and Development' for a list of students trained as part of the Jornada Basin LTER Program.

Postdoctoral Training:

Several Jornada Basin LTER scientists have hosted postdoctoral associates in their laboratories, including:

Dr. Maria del Carmen Mandujano (with Laura Huenneke at NMSU)
Dr. R.E. Miller (with Laura Huenneke at NMSU)
Dr. Habin Li (with J.F. Reynolds at Duke)
Dr. Antonio Gallardo (with W.H. Schlesinger at Duke)
Dr. Hormoz BassiriRad (with J.F. Reynolds at Duke)
Dr. J.L. Chen (with J.F. Reynolds at Duke)
Dr. D.C. Tremmel (with J.F. Reynolds at Duke)
Dr. A.G. deSoyza (with J.F. Reynolds and R.A. Virginia)
Dr. A.C. Franco (with J.F. Reynolds and R.A. Virginia)

Contributions to Science and Technology Infrastructure:
1. The field program at the Jornada Basin LTER includes several long-term experiments that have been established for the benefit of LTER researchers and others who propose to work there. These include two large-scale field experiments:

Stressor Experiment: The stressor experiments consist of two sets of eighteen 70 x70m experimental plots located in areas in which mesquite shrubs are beginning to invade the native black grama grasslands. These plots receive one of the following treatments in a 2 x 3 factorial design replicated in 3 blocks: Vegetation (shrubs removed or left intact) x Grazing (None, summer, or winter). Grazing is conducted in an acute, intense treatment (2 days) in each season. Currently, the stressor plots are monitored for changes in plant cover and productivity, changes in soil characteristics and heterogeneity, and changes in surface temperature and albedo. Permission to work in these plots should be requested from Dr. Kris Havstad of the USDA/ARS/Jornada Experimental Range

Biodiversity Experiment: The biodiversity experiment consists of manipulations within 25 x 25 m plots in a mixed desert shrubland environment to alter the presence of certain growth forms and the overal diversity of the plant community, viz.:

1) Control
2) Growth form removals:
    -all shrubs removed
    -all perennial grasses removed
    -all sub-shrubs removed
    -all succulents removed
3) Simplified vegetation
-only a single species (the dominant) of each growth form remains
4) Reduced vegetation'
-the dominant of each growth form is removed, including all Larrea
-the dominant of each growth form is removed, including all mesquite

Each treatment is replicated once, in a random location, in each of 6 experimental blocks, all within a 250 x 250 m area, of relatively uniform topography and initial vegetation. Field studies since 1995 have documented changes in the composition and abundance of herbaceous vegetation, grasshoppers and ants, changes in the demography of shrub vegetation and changes in the erosion of soils. Permission to conduct further studies on these plots should be requested from Dr. Laura F. Huenneke, Department of Biology, New Mexico State

University.

2. NSF supplemental funding to the Jornada Basin LTER, has allowed us to expand the size, improve the curation and computerize the database of the biodiversity collections within the Biology Department at New Mexico State University-including collections of plants, reptiles, and insects from our intensive study sites.

3. NSF funding for the Jornada Basin LTER has supported the development and maintenance of our website (http://jornada.nmsu.edu), which contains a variety of species lists, climatic data and long-term data collected in core area studies. The site describes our standard procedures for data collection, management and access, and most datasets are unrestricted for public use. The site also contains descriptive information about the Jornada Basin LTER program, documents of its activities (The Jornada Trails Newsletter, annual reports etc). Further information about the website can be obtained from John Anderson, Department of Biology at New Mexico State University. (See also NSF Fastlane Webpage on 'Other Products.'

4. The Jornada Basin LTER also maintains a Geographic Information System (GIS), which can provide field researchers with a variety of maps and map-overlays of natural and anthropogenic features of the Jornada Basin. The archive includes a representation of airborne and satellite remote sensing from AVHRR, AVIRIS, Daedalus, and LANDSAT-TM sources.

Beyond Science and Engineering:
During the past year, the Principal Investigator for the Jornada Basin LTER, William H. Schlesinger, has been involved in a number of activities to increase public awareness and improve the information available to Congressional leaders regarding the UN Convention to Combat Desertification. Schlesinger spoke at a Smithsonian Conference on changes in soil properties associated with desertification, and Schlesinger and Laura Huenneke coauthored the following letter, which appeared in the Las Cruces Sun News, regarding the impact of potential US participation in this international convention on New Mexico.

'The Desertification Convention: New Mexico Stands to Benefit

Within the next few weeks, the Senate may choose to ratify the United Nations Convention to Combat Desertification. A successful vote would add the United States to the list of 145 other nations that will pool their knowledge and expertise to combat land degradation throughout the world. Not without its own problems of land degradation, New Mexico has a lot to offer to the U.N. Convention. More than 100 years of basic and applied research at the Jornada Experimental Range near Las Cruces have helped improve the management of many rangelands. Several decades of field studies by faculty at the University of New Mexico and New Mexico State University have helped us understand the causes and consequences of desertification throughout the southwestern United States.

The causes of desertification, often associated with the invasion of grasslands by mesquite, are hotly debated. Livestock grazing, fire suppression, rising concentrations of atmospheric carbon dioxide, and climate fluctuations have all been implicated in the loss of productive grasslands in New Mexico. Desertification is often associated with a loss of soil fertility from erosion by wind and water. Developing better methods of sustaining vegetation in the semiarid lands of New Mexico will reduce soil erosion and the long-term loss of fertility that usually accompanies desertification. The U.N. Convention would pledge the help of U.S. scientists, range managers, and engineers to better understand and control the problem of land degradation worldwide.

And desertification is a worldwide problem. Nearly 20 per cent of the world's population lives at or near the borders of deserts, where land degradation is most severe. In most cases there is no alternative to cultivation and livestock production to sustain the local population. In recent years, the U.S. has sent humanitarian aid and peacekeeping forces to a variety of regions throughout the world where drought and crop failure have led to instability and famine. Further research, spurred by U.S. participation in this treaty, can only help land managers better understand the process of land degradation in New Mexico, and at the same time contribute their expertise to help slow desertification in other nations of the world. To the extent that the U.N. Treaty can offer an ounce of prevention, it will be worth several pounds of cure to the U.S. taxpayer.'

Ties to Other Regions of the U.S.

Jeff Herrick and Kris Havstad, LTER project scientists, have developed methods to monitor the 'health' of rangelands, and they are promoting their efforts throughout the Southwestern U.S.

Ties to Scientists and Programs in Mexico

The Jornada LTER was represented at a meeting in Durango, Mexico in June 1999, where our scientists presented strategies for rangeland monitoring and management based on Jornada research. The meeting organizer, who is also director of the national laboratory for water management, plans to visit the Jornada later this year to discuss further collaboration. Collaboration between the Jornada-ARS and scientists based at La Campana continues on development of ecologically-based monitoring protocols.

Scientists with the Universidad Juarez del Estado de Durango, Facultad de Agricultura y Zootecnia and Jornada LTER scientists completed a study comparing Landsat spectral images of soils and vegetation at the Mapimi Biosphere and the Jornada Basin. Collaboration continues between Jornada LTER scientists and scientists with the Universida Autonoma de Ciudad Juearez on sustainable ecological and groundwater development along the US-Mexico border.

Special Requirements

Special reporting requirements:

Change in Objectives or Scope:

Unobligated Funds:

Animal, Human Subjects, Biohazards:

Categories for which nothing is reported:

Any Journal
Any Book
Contributions: To Any Other Disciplines
Change in Objectives or Scope: None
Special Requirements for Annual Progress Report: None
Change in Objectives or Scope: None
Unobligated funds: None
Animal, human subjects, biohazards: None