2000-2001 Annual Report, Sevilleta LTER Program (NSF Grant 0080527)

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I. Activities

Since the establishment of the Sevilleta (SEV) LTER program in 1989, our overall objective continues to be to provide ecological understanding and biophysical and mechanistic models of multiple transition zones interacting across a range of spatial and temporal scales. The dominant life forms of a floristic region have profound effects on ecosystems, and research at SEV is important in understanding how ecological processes are affected by the intermingling of life forms from adjacent biomes and the changes caused by movement of one life form into the habitat of another. The current program expands ongoing studies by initiating additional research focused at a mechanistic understanding of the control of ecological and ecosystem processes by external and internal drivers. Our five core study sites, placed in areas representing different life forms and zones of overlap are information "nodes" that allow integration of abiotic and individual, population, community and ecosystem properties at specific points along transition gradients. Less intensive studies, experiments, surveys of other variables, and modeling across the intervening areas between core sites provide the basis for extending the understanding from points to the gradients represented by SEV.

Goals: Our first goal is to understand controls on ecological properties and processes influencing transition zones between biomes (i.e., ecotones) and to predict the dynamics of transition zones as these controls change over time. A second major goal addresses the effects of transition zones on biodiversity at different spatial scales. For goal 1, a major organizing theme is that the different transitions are structured by the same general processes; however, these processes play out differently due to different environmental conditions (soil, disturbances, microclimate, climate, topography) interacting with plant and animal life history strategies. We predict that plant-level processes (recruitment, growth, and mortality) interacting with climate, disturbance, soils, and fauna result in the range of patterns in vegetation and ecosystem processes that define the different biomes. Patterns vary over multiple spatial and temporal scales and resultant properties (structure, biomass, diversity, nutrient quality) and dynamics produce important feedbacks that maintain the ecological processes that define different biomes. The multiple transition zones, controlled by different factors, allow the generality of these predictions to be tested by studying both within (grass/grass, tree/tree) and between growth forms (grass/shrub, shrub/tree, grass/tree). Comparisons also can be made with the biomes represented by other sites.

For our second goal, the uncommon associations of multiple floras and life forms representing deserts to forests are assumed to create conditions promoting atypical community assemblages and species interactions. We predict that the high diversity of life forms and life-history strategies of the multiple biome transition zones will result in both a high local and regional pool of species, increase sympatry, and increase species population dynamics (increased variation in population densities).

Based on our LTER-III (2000-2006) renewal proposal to NSF, the LTER Review Panel recommended a two-year funding period, during which time we should initiate our new studies and continue our long-term data sets, but work on increasing the connectivity among all of our studies. During the past year, we have held weekly meetings with all local Co-PIs and staff (along with a January 2001 symposium meeting with all Sevilleta participants) with the goal of creating an intellectually and logistically more-integrated research program. These meetings have led us to consolidate a number of our studies, and emphasize a series of highly-integrated pattern and process studies at the transition zone between Chihuahuan Desert shrub vegetation and the shortgrass steppe vegetation on the Sevilleta study site. Some of the studies in the transition zones of the pinyon-juniper woodlands will be reduced or postponed, so that our resources can be applied to intensive studies at the desert/grassland transition. This reallocation of research effort will be reflected in our upcoming renewal proposal in January, 2002.

In view of our proposed emphasis on the desert/grassland transition, many of our field activities this year have concentrated on this site. We have established a new meteorological station in our new blue grama grass (*Bouteloua gracilis*) site in conjunction with our existing array of 9 weather stations on the Sevilleta Refuge. In addition, Sevilleta's array of precipitation gauges was greatly supplemented by an array of gauges installed by a NASA-funded project as part of the Tropical Rainfall Measurement Mission (TRMM). This network consists of 21 datalogger-equipped rain gauges with some of these gauges equipped with temperature and relative humidity sensors as well.

We also have established three new vegetation transects, each of which spans a 6-km ecotonal gradient from desert shrubland through black grama grass (*B. eriopoda*) to blue grama grass. These have been measured using 10-meter wide belt transects along their entire lengths, and these vegetation data have been supplemented with high-resolution color and IR aerial photographs. In addition, a large number of vegetation “patches” (representing shrubs, black grama and blue grama domination) of different sizes have been identified and mapped, and will form the basis for our long-term studies and manipulation experiments. Along with plant and soil measurements across this ecotone, we have established sampling transects for small mammals and arthropods, and have begun analyzing the patterns for the major taxa (Rodentia, Aranea, Insecta).

A major field experiment has been initiated using rain-out shelters constructed in the desert/grassland ecotone. The construction of the rain-out shelters is nearly finished, and the first experiments are scheduled to begin this fall/winter.

In addition to these new studies, Sevilleta researchers continued field work for a number of projects to characterize long-term dynamics in a range of biotic variables in the five core ecosystems of the Sevilleta: the cross-site small mammal exclosure study; the Sevilleta grasshopper population study; ground-dwelling arthropod population study; rodent populations study; plant transect study; and NPP study. Results of all these studies are presented in the Findings Section of this report.

II. Findings.

The results of the 2000-2001 research activities are reported below. In total, researchers with the Sevilleta LTER Program have produced 47 peer-reviewed scientific journal articles and five book chapters/reports/dissertations during 2000-2001.

Sevilleta 2000-2001 Weather Results: Mid-range climatic predictions (months to seasons) are recognized to be tenuous at best. The 2000-2001 period demonstrated this to an extreme. La Nina conditions often seem to translate into earlier and stronger monsoon for the Sevilleta region and with the area locked in a 3rd La Nina year it was thought that the 2000 monsoon would likely be wetter than normal and was predicted as such by the Climate Prediction Center. This proved to be false when it turned out to be the 3rd driest June through September in Sevilleta's 12 year history.

ENSO is actually considered to be a better predictor of non-monsoon precipitation in the southwest and as such it was presumed that the 2000-01 winter would be dry as had been the previous 2 La Nina winters. This again proved to be false as the Oct. 2000 - May 2001 came in as the second wettest in Sevilleta's 13 year record; the only wetter Oct.-Jun was during the El Nino of 1991-92.

With 12 full years of meteorological monitoring, database management continues to be a major part of the meteorological effort. Efforts continue to increase meteorological-climatological information available through the Sevilleta LTER home page. This includes both raw data and daily, monthly and annual summaries. This information can be accessed via the Sevilleta - Climate Meteorology Home page at the following URL: http://sevilleta.unm.edu/research/local/climate.

Soil moisture measurements: Soil moisture studies are critical to understanding the dynamics of plant and animal populations, as well as nutrient cycling/decomposition. Particular emphasis is being placed on how soil moisture changes across the Sevilleta's various ecosystems, especially in the ecotonal regions. Soil moisture studies across Sevilleta ecotone study areas were conducted in 2001 by Co-PI Jan Hendrickx, from the NM Institute of Mining and Technology. Dr. Hendrickx and his students have made progress in two areas. They have analyzed six LandSat images and derived actual ET and soil moisture conditions over the entire Sevilleta LTER site. Qualitative validation looks promising. Quantitative validation will be conducted in the fall of 2001. They also have surveyed two of the three 6 km transects with the EM38 instrument (ground-penetrating radar unit for measuring soil moisture), taking measurements every meter. Preliminary data analysis reveals the homogeneous areas along the transects. The LandSat images will be overlain with the EM images in the fall of 2001.

In addition to soil moisture measurements by Dr. Hendrickx, Co-PI Eric Small has been conducting measurements of water and energy balance across the grass-shrub transition zone on an area known locally as McKenzie Flats (the major study site of the Sevilleta LTER Program). Dr. Small and his team have monitored the exchange of water and energy between the land surface and atmosphere across the shortgrass steppe-

Chihuahuan Desert scrub transition. Measurements of sensible and latent heat flux, radiation, soil moisture, and other variables were recorded at three sites: pure grass, mixed grass and shrub, and pure shrub. Dr. Small has found that the temporal variability in surface-atmosphere exchanges associated with wetting-drying cycles far exceeds the differences associated with vegetation type.

In addition, Small's research group has examined the spatial patterns of infiltration in grass and shrub ecosystems. They measured the pattern of infiltration following six rain events using Time Domain Reflectometry (TDR) and trenching to expose wetting front depth. Spatial surveys were completed with a resolution of 10 cm, over distances of ~20 m. Infiltration beneath plant canopies exceeds that within interspaces, in both grassland and shrubland. The intensity of the canopy-interspace infiltration contrast depends strongly on storm type and surface slope. More intense storms and steeper slopes yield more surface water redistribution and a greater canopy-interspace infiltration contrast. There is not noticeable difference in the length scale of spatial variability in grass and shrub environments.

Vegetation-Moisture Experiments: As part of the long-term assessment of climate controls on plant dynamics in the Sevilleta's ecosystem transition zones, Dr. Small and Co-PI Will Pockman have begun an experiment using rain-out shelters constructed on McKenzie Flats. They have constructed 9 rainfall manipulation plots at the shrub-grass ecotone. Three of the plots have structures to limit rainfall. A portable sprinkler system is used to add water to three others. Finally, there are three controls that receive only ambient rainfall. They have installed over 350 soil moisture and water potential probes in both vertical and horizontal arrays. Rainfall and runoff are also measured. They also have completed thirty 10-m long vegetation transects across the plots. These are being linked to digital camera surveys completed using a camera on a boom. Rainfall treatments will begin in October 2001. This project was primarily funded by the NSF SAHRA STC, with supplementary support from the Sevilleta LTER.

Freezing and plant distribution: During winter 2000-2001, Co-PI Will Pockman conducted the first experiments to understand the importance of interruption of xylem water transport during freezing conditions for determining the northern limit of *Larrea tridentata.* Based on previous results from Arizona, he predicted that populations of *L. tridentata* in the Chihuahuan desert would possess xylem more resistant to freezing-induced embolism. This prediction was only weakly supported. The Sevilleta populations were only slightly more resistant to freezing-induced embolism even though the temperature conditions that they experience annually are much colder than those previously studied in Arizona. Dr. Pockman suspects that the extensive standing dead wood and the significantly higher levels of embolized xylem present in stems of the Sevilleta population reflect greater freezing damage associated with the colder climate. This suggests that the northern limit of the species may be associated with climatic conditions where the level of freezing damage exceeds the ability of the plant to sustain growth and reproduction over the long term. These findings will be submitted for publication during August 2001 and these experiments will continue during the coming

year. They will also be part of the Ph.D. dissertation of Jordi Martinez-Vilalta at the Free University in Barcelona, Spain.

Ecotone patterns of vegetation: Co-PI Esteban Muldavin has collaborated in the design and implementation of a series of belt transects across Mackenzie Flats. These three 6-km long transects are intended to cross several ecotones between creosotebush, black grama and blue grama dominated communities. For the initial vegetation analysis, the transects have been partitioned into 10x10 m contiguous quadrats in which the abundance of all shrubs, grasses and major perennial forbs have been evaluated (summer 2001). These quadrats will be subjected to pattern analysis to identify and characterize the various ecotones and their local landscape context during the fall of 2001.

At a larger scale, Dr. Muldavin also has been conducting a formal floristic analysis of the Sevilleta LTER position as a transition between Chihuahuan Desert, Great Basin Desert and Shortgrass Steppe biomes. Vegetation data collected from the Sevilleta (reconnaissance and NPP plots) is being compared against a northern Chihuahuan Desert dataset comprising plots from the Sierra del Carmen in Coahuila MX and Ojo Caliente in Chihuahua MX; Big Bend National Park, TX; Carlsbad Caverns National Park, Otero Mesa, Tularosa and Jornada basins of southern New Mexico, and the Malpais Borderlands area of southwestern New Mexico and southeast Arizona. In addition, datasets are currently being developed from the southeastern Colorado Plateau and from the Short Grass Steppe region of northeastern New Mexico for a similar analysis of floristic relationships. Preliminary results will be presented at the August 2001 meeting the Botanical Society of America.

Effects of disturbances on vegetation patterns in Sevilleta ecotones: Small scale disturbances. Co-PI Deb Peters is continuing to examine the effects of small, patchy disturbances on vegetation dynamics at ecotones through experiments and simulation models. She continues to monitor the 3m x 4m removal plots at five sites located along a grassland-shrubland ecotone on McKenzie Flats as well as a sixth site along the foothills of Los Pinos that represents a predominately blue grama community with very small amounts of black grama and no creosotebush. The five sites have been monitored since 1995 and the sixth was added in 1998. Initial results show that removal of blue grama, black grama or creosotebush have very different effects on the remaining plant community (Peters 2000, 2001 ESA and IALE presentations). Removal of blue grama results in invasion by perennial grasses from surrounding the plots whereas removal of black grama results in positive responses by perennial forbs on the plots. Removal of creosotebush also results in growth of plants on the plots at the time of removal, but these plants are primarily annuals. These plots will continue to be monitored annually for plant responses following removal of the dominant species. Long-term monitoring is needed to determine the species that dominates following the loss of the current dominant. Dr. Peters and her team also investigated the role of kangaroo rats in generating and maintaining plant species diversity at patch to landscape scales (Kroel-Dulay et al. 2000, 2000 ESA and ASM). They examined the contribution to species richness across spatial scales by kangaroo rat mounds located either in patches dominated by blue grama or black grama. They found that the area affected by the burrowing activity of kangaroo rats

was twice as large in black grama patches compared with blue grama patches. Furthermore, dominant species on mounds in black grama patches were also abundant in off-mound areas whereas plant species on mounds in blue grama patches were not as abundant off-mound. These results indicate that the presence of mounds in blue grama patches is creating islands of plant communities that are distinct from the rest of the grassland.

Plant population studies of important species: Because of the importance of black grama and creosotebush in Chihuahuan desert ecosystems, and of blue grama in shortgrass steppe grasslands, the plant population studies are focusing on these three species (Co-PI Deb Peters).

Recruitment: A multilayer, daily time step soil water model (SOILWAT) was used to evaluate the probability of seedling establishment for black grama and blue grama (Peters 2000 JVS). She evaluated the effects of climatic variation across multiple temporal scales (seasonal, inter-decadal, and long-term directional) on the probabilities of establishment for each species at the SEV. She found that the two species have different regeneration strategies. Blue grama has a broad pattern of establishment that occurs from May through September, and includes years with high year-to-year variation in precipitation. By contrast, black grama has a narrow distribution of establishment events that occur primarily in July when precipitation amounts are most reliable. She also found that climatic conditions from 1949-1968 were more favorable for black grama compared with the cooler, wetter period from 1969-1988 that favored blue grama. Although these simulation results need to be tested in the field, they suggest one mechanism by which blue grama and black grama can either codominate or shift dominance through time as the weather conditions change.

Using field studies, Dr. Peters also found that black grama and blue grama have different strategies related to seed production and seed presence in the soil (Peters JVS in review). High seed production, yet low viability by black grama was accompanied by few seeds stored in the soil. By contrast, blue grama produced fewer seeds with higher viability and a greater proportion of seeds produced were found stored in the soil. Combining these results with the analyses of seedling establishment, we conclude that recruitment of black grama is more limited by the availability of viable seeds whereas blue grama is more limited by seedling establishment at the SEV.

Competition for soil water: Dr. Peters conducted a field study to examine the spatial and temporal acquisition of soil water by the three dominant species (Peters Ecol. Modlg submitted). Watering experiments were conducted followed by measurements obtained using time domain reflectrometry (TDR) for three depths (0-5, 0-20, 0-30cm) in early spring (April) and summer (late May). Results show that blue grama acquires water at cooler temperatures than black grama, and that creosotebush acquires water at a broad range of temperatures and soil depths. These results indicate that spatial and temporal partitioning of soil water is an important mechanism allowing coexistence by these three species at this ecotone.

Plant community studies: Sevilleta LTER researchers are also investigating patterns in species diversity across multiple spatial scales, from individual plants to patches and the landscape. The objective was to determine if encroachment by creosotebush results in a reduction in diversity of the plant community compared with black grama grasslands (Hochstrasser 2001). At all three spatial scales, the shift from grasses to shrubs was not associated with species loss. The encroachment of grasslands by shrubs increased the spatial heterogeneity of the vegetation and as a consequence, species diversity also increased. These results conducted at an ecotone between grasslands and shrublands are in contrast to previous studies that compared communities where creosotebush-dominated areas were found to have decreased diversity compared with black grama grasslands. Thus, initial encroachment by shrubs may lead to high species diversity. As shrubs increasingly dominate the community, grasses and forbs are lost and species diversity declines.

Long-term changes in vegetation: Sevilleta LTER researchers Dan Ryerson and Bob Parmenter examined vegetation change following the removal of keystone herbivores from the Sevilleta (Ryerson and Parmenter, 2001). In this study, they evaluated vegetation changes on 30 sites within and adjacent to Sevilleta National Wildlife Refuge over a 20-yr period following removal of the major mammalian herbivores (livestock and prairie dogs) in 1972-1975. The study sites were established in 1976, and were resampled in 1986 and 1996 using line transect methods. At the landscape scale, repeated measures ANOVA of percentage cover measurements showed no significant overall net changes in total perennial plant basal cover, either with or without herbivores present; however, there was an overall increase in annual forbs and plant litter from 1976 to 1996. At the site scale, significant changes in species composition and dominance were observed both through time and across the SNWR boundary. Site histories varied widely, with sites dominated by *Bouteloua eriopoda* (black grama grass) being the most dynamic and sites dominated by *Scleropogon brevifolius* (burro grass) being the most persistent. Species-specific changes also were observed across multiple sites: *B. eriopoda* cover increased while *Gutierrezia sarothrae* (a small, short-lived shrub) greatly decreased. The non-uniform, multi-directional changes of the sites' vegetation acted to prevent detection of overall changes in perennial vegetation at the landscape level. Some sites displayed significant changes after removal of herbivores, while others appeared to respond primarily to climate dynamics. Certain species (e.g., *G. sarothrae*) that were not preferred by livestock or prairie dogs, showed overall declines during drought periods, while other preferred species (e.g., *B. eriopoda*) exhibited widespread increases during wetter periods regardless of herbivore presence. Therefore, the vegetation dynamics could not be attributed solely to removal of mammalian herbivores, and in some cases could be explained by short- and long-term fluctuations in climate. These results emphasized the variety of responses of sites with differences in vegetation to mammalian herbivores under otherwise similar climatic conditions, and illustrated the value of site- and landscape-scale approaches to understanding the impacts of plant-herbivore interactions.

Vegetation Patch Characterization: Sevilleta LTER researchers (Co-PI Deb Peters et al.) are characterizing patches at the Sevilleta using field studies and mapping. Our initial

characterization involved comparing plant species composition between blue grama- and black grama-dominated patches (Kroel Dulay et al. submitted). We hypothesized that subordinate species at this biome transition zone would be associated with plant communities from the adjacent biomes. The alternative hypotheses are that each species is either associated independently with different patch types or distributed randomly. We tested these hypotheses by conducting spatially-explicit sampling of blue grama and black grama dominated patches. We found that most species were associated with one of the two patch types. Of the 52 species found, 16 were significantly associated with blue grama patches and 12 were associated with black grama patches. However, these subordinate species found within the different patches were not characteristic of the shortgrass steppe or Chihuahuan desert biome, respectively. Thus, patch types have characteristic life form and species composition, but patches do not represent the adjacent biomes in these features. Species respond independently to changes in environmental factors and not as plant communities.

We recently began mapping patches of dominant species located throughout the McKenzie Flats. In March (2001), we mapped > 250 patches of creosotebush in 3 belt transects near Five Points. Each patch was geo-referenced, the number of shrubs was counted, and the perimeter was outlined and mapped using the GPS unit. We also characterized the vegetation inside and outside each patch. We also mapped the perimeter of blue grama patches located between Deep Well and Five Points as part of our new patch focused effort.

Synthesis using simulation modeling: Sevilleta LTER researchers are using simulation modeling to evaluate long-term effects of climate, small disturbances and soil texture on species dominance and plant community composition. The ECOTONE individual based model simulates the size and age of each plant on a small plot through time at an annual time step. ECOTONE contains a similar formulation as found in forest gap models, including the mortality routines (Keane et al. 2001). We conducted simulation analyses of the importance of soil texture to patterns in species dominance and composition under current climatic conditions and under a directional change in climate (Peters, Ecological Modelling, submitted). Blue grama and black grama codominated sandy loam soils and black grama and creosotebush codominated loamy sand soils under current climatic conditions. These results are comparable to observed patterns on the McKenzie Flats. Under a directional change in climate that increased summer precipitation and temperature, black grama clearly dominated sandy loam soils and increased in importance on loamy sand soils. These results suggest that an increase in summer precipitation could alter the species dominance patterns at the SEV with an increase in dominance by black grama. We also conducted simulation model analyses of the effects of disturbance frequency on dominance by blue grama, black grama or creosotebush (Peters and Herrick 2001). We found that dominance by blue grama decreases and dominance by black grama increases as disturbance frequency increases; creosotebush was unaffected over the range of disturbance frequencies investigated. These simulation results complement previous field studies showing that black grama responds positively to the presence of kangaroo rat mounds whereas blue grama is negatively affected (Fields et al. 1999).

In the previous ecotonal phase transition studies, Li (1995, 2000, 2001) and Loehle et al. (1996) demonstrated that if ecotonal phase transitions occur the systems must be unstable. In order to test this in grass-grass interaction system of Sevilleta, Co-PI Larry Li used 10 years of vegetation transect data at Deep Well (shortgrass steppe grassland) and Five Points (Chihuahuan desert grassland) to reconstruct spatial and temporal dynamics of blue and black grama interactions. Treating such reconstruction as mathematical inverse problem of differential equations, he reconstructed a series of models to describe interacting blue-black grama dynamics along spatial gradient as well as temporal variations. From these models, he derived their corresponding community matrices. Using local stability analysis, he analyzed their dynamic properties of blue and black grama interactions. Dr. Li found that most of blue and black grama interactions in both of sites spatially and temporally were not stable (especially few of them with no valid equilibrium solutions), which indicated that during the past ten years transitions might be undergoing in shortgrass steppe and Chihuahuan desert grasslands. He also compared interspecific competition coefficients with blue or black grama intraspecific competition coefficients at both sites. He found that the role of black grama in such blue-black grama interactions is relatively greater than blue grama at Five points; at Deep Well both of species showed relatively moderate in comparison with self-feedback of either species in space or time. In addition, spatial partitioning of both species was also evident. Li is further analyzing the role of biotic or abiotic factors in such phenomena. Thus far, he found very limited role of abiotic factors such as precipitation in shaping ecotone transitions of shortgrass steppe and Chihuahuan desert grasslands. The detailed analyses will be included in Xuefei Wang's thesis, which is scheduled for the defense on 24 August, 2001. The title of the thesis is "Temporal and spatial structures of black and blue gramas: statistical analysis of biotic and abiotic interactions from Sevilleta vegetation transect data."

Studies on mycorrhizal fungal communities. We have focused on describing the ecosystem functioning of mycorrhizae and the spatial structure of mycorrhizal fungal communities. To date, we have found that all of the dominant plant species form mycorrhizae. This includes creosote bush, which has been previously reported as nonmycotrophic. However, there are major shifts both within communities and between communities that will form the basis of future research. Mycorrhizal fungi influence root production and turnover. However, it appears to be plant and fungal species specific, with few generalizations to date. However, root tips can be shed and are analogous to leaves, with some persisting multiple years, and many for a very short time. Different species of EM fungi have different persistence rates. d14C and minirhizotron observations have shown that individual root tip longevity varies by fungal species. Juniper root (AM) have short lifespans with little variation among individual tips.

Pinyon pine, oaks, and cottonwood all form ectomycorrhizae (EM). Pinyon pine forms EM with over 50 species of fungi. Analysis of the fungi across space shows that there are 5-9 species of EM fungi associated with any one tree. This increases to about 20-30 within a 30 X 30m stand. However, as one moves across the landscape, the richness continues to increase even though diversity indices don't change. Thus, there appears to be replacement of minor species continuously across the site. We have shown that oaks

form both arbuscular mycorrhizae (AM) and EM. The colonization pattern separates in space and time. Importantly, some species are the same as found across the southwestern US. We have demonstrated that cottonwood forms mycorrhizae deep into the soil profile in the Rio Grande Valley. We are currently studying the morphotypes to determine if the fungi are a subset of surface fungi, or different species altogether.

All other important plants form AM. However, some important patterns emerge. In the forested uplands, juniper and the grasses form AM with the major genera of AM fungi, including Gigaspora, Scutellospora, Acaulospora, and Glomus. However, in the grassland and desert flats, only members of the genus Glomus can be found. There are some species differences between the grasses at the north end of the site, and those associated with Creosote in the south.

Animal studies: Arthropods. During 2000-2001, Sevilleta LTER Co-PIs Bob Parmenter and David Lightfoot continued studies on arthropods, including surface-active arthropod assemblages (pitfall trap studies), plant-dwelling arthropod assemblages

(D-Dac studies and insecticide application studies), and grasshopper assemblages (belt transects). Analyses of surface-active arthropods have focused on compositional differences and spatial patterns of taxa across the Sevilleta ecotones; species with general- and microhabitat preferences have been identified, and new studies concerning the environmental factors that limit their distributions have been initiated. In addition, Parmenter and his REU student, Brian Sanchez, conducted a study that examined the arthropod communities on creosotebushes across the ecotone of desert scrub to grassland. They found the patterns observed were consistent with Island Biogeographic Theory, with fewer species of creosotebush "specialists" being found on distant "island" shrubs in a "sea" of grassland (Sanchez and Parmenter, in press). In addition, population sizes of herbivorous arthropods were smaller on distant "island" shrubs, in concert with increased numbers of predatory arthropods (spiders and mantids). This significantly small herbivore load was hypothesized as one of the factors for the success of creosotebush in invading grasslands of the Southwest.

In addition, a new monitoring program for pollinators (native bees) was initiated in February of 2001 by LTER field technician Karen Wetherill. The study involves trapping bees using Moericke traps on a monthly basis. During the first two years of this study, the primary goal is to develop a voucher collection of Apoidea and to identify all bees present to the species level. These data will be compared with the data collected from the plant phenology study that began in February of 2000 to look at community structure of the flowering plant populations and their pollinators. There are three study sites, creosotebush shrubland, black gramma grassland, and blue gramma grassland. In the first five months of trapping, about fifty species have been collected. Ms. Wetherill will start her Ph.D. work with the Sevilleta LTER in 2003.

Mammals. During 2000-2001, LTER Co-PIs Bob Parmenter and Terry Yates continued studies on rodents, rabbits, and coyotes. Data from the rodent studies were incorporated into analyses testing the "Trophic Cascade Hypothesis" to ascertain the drivers of rodent

population increases and crashes, and to predict outbreaks of zoonotic diseases (hantavirus and plague). Drs. Yates and Parmenter incorporated satellite AVHRR NDVI values for the McKenzie Flats region of the Sevilleta, ground-truthed percentage cover data of vegetation in the same area, climatological data, and the rodent data to develop a predictive model for the trophic cascade and eventual risk of zoonotic disease. These results were submitted in a manuscript to Nature in July, 2001 (Yates et al., submitted).

The rodent data set, along with plant cover data, arthropod data, and rabbit data, were synthesized in a study of coyote diet shifts with climate fluctuations on the Sevilleta. These analyses, conducted by Bob Parmenter in collaboration with Dr. Lucina Hernandez (Instituto de Ecologia, Durango, MX), showed that coyotes exhibited high dietary breadth, but seemed proficient at preying on rabbits regardless of rabbit abundance (Hernandez et al., in press). The 10-year data set also revealed that jackrabbit and coyote populations on the Sevilleta do not show the typical 9-11 year cycles that are common in the Great Basin Desert; this lack of cycling was attributed to the greater diversity of prey types available on the Sevilleta, and the less severe winter conditions that "de-coupled" the coyote populations from their primary prey, the black-tailed jackrabbit (Hernandez et al., in press).

Another small mammal study is being conducted by graduate student Ana Davidson. Her Ph.D. dissertation title is: "Comparative Effects of Gunnison's Prairie Dogs and Banner-Tailed Kangaroo Rats on Vegetation, Grasshoppers, and Lizards in a Semi-Arid Grassland." In this study, vegetation, grasshopper, and lizard data were collected around prairie dog and banner-tailed kangaroo rat mounds and adjacent "non-mounds," and on the prairie dog colony and off the colony (where only kangaroo rats occur, kangaroo rat site). Davidson's initial results demonstrated that Gunnison's prairie dogs and banner-tailed kangaroo rats had significant influences on plants, grasshoppers, and lizards. However, they appeared to affect plants and animals at different scales. In general, the patterns found in plants, grasshoppers, and lizards on the colony tended to be similar to those found on the mounds. Species known to be associated with disturbance or bare soil tended to be more common on the colony and mounds (i.e., annual plants, certain arthropods, and lesser earless lizards). The kangaroo rat sites tended to demonstrate similar patterns to that of the non-mound areas. Species known to be negatively associated with disturbance, or associated with grasses were more common off the colony and off the mounds (i.e., perennial plants, certain arthropods, and whiptail lizards). These preliminary results indicate that the prairie dog colony and mound areas probably had a greater degree of disturbance.

Ground-dwelling arthropods were also sampled from prairie dog and kangaroo rat burrows. Davidson's results indicate that prairie dog and banner-tailed kangaroo rat burrows provided important habitat for many arthropod species (e.g., tenebrionid and spider beetles, and some species of ants, cockroaches, scorpions, centipedes, camel crickets, and ticks), including rodent burrow specialists (Formicidae: *Aphaenogaster puntaticepts*; Gryllacrididae: *Ceuthophilus fissicaudus*). The burrow systems of prairie

dogs appeared to provide more favorable microhabitats for some species (camel crickets and ticks), while other species seem to prefer the microenvironment provided by kangaroo rat burrows (spider beetles). The results from her initial data indicate that prairie dogs and kangaroo rats increased habitat heterogeneity, and their modifications of above and below ground habitat appeared to benefit a number of plant and animal species.

Finally during 2000-2001, in collaboration with the U.S. Fish and Wildlife Service, we have continued radio-telemetry and aerial survey studies of pronghorn antelope on the Sevilleta refuge, and are starting a long-term study to measure abundances and distributions of mule deer populations. Once the densities and distributions of these large herbivores is documented, energetics models will be developed to assess their impacts on preferred plant species and their responses to climate dynamics.

Granivore Studies (Mammals, Birds, Ants). Sevilleta LTER graduate student, David Whalen, has been working on his Ph.D. dissertation, entitled, "Resource Allocation Among Granivores across a Grassland-Shrubland Ecotone." Recent studies have demonstrated that, despite fluctuations in species composition, species diversity is often a fairly invariant and seemingly emergent property of ecosystems. The invariance of species diversity suggests that species must subdivide resources in a constant and regular manner. In other words, there must be some very fundamental rules that govern how resources are allocated among species within a community. This project is investigating the role that multi-scale vegetation and resource distribution patterns play in the allocation of resources among granivores at a grassland-shrubland ecotone. Sixteen study plots have been established among desert grassland and creosote shrubland habitats on the Sevilleta National Wildlife Refuge. At each of these locations, late summer (post-monsoon) surveys of seed-eating ant populations (primarily *Pogonomyrmex* spp.) and fall, winter, and spring surveys of granivorous birds are being conducted. These surveys, combined with ongoing rodent trapping activities within the area, are being used to make estimates of population-level energy use within the granivore community. In addition, summer and winter seed foraging experiments have been conducted at each study plot. Consumption of seeds in patches spanning several orders of magnitude (10^0 - 10^3 seeds) by ants, rodents, and birds were measured at 400 subplots. The effects of seed density and vegetation structure on seed consumption patterns are currently being assessed. Along with some additional experiments, this information is being used to examine how resources are allocated within a community that includes species spanning a range of body sizes and foraging scales. This project is scheduled for completion in Spring 2003.

Other Sevilleta LTER field studies: During 2000-2001, Sevilleta researchers continued field work for the following field projects, to characterize long-term dynamics in a range of biotic variables in the 5 core ecosystems of the Sevilleta: the cross-site small mammal exclosure study; the Sevilleta grasshopper population study; ground-dwelling arthropod population study; rodent populations study; plant transect study; NPP study.

Remote-sensing/GIS/GPS/System Administration for LTER 2000-2001: The IFSAR 2.5 m resolution radar imagery, and the 10 m resolution radar-derived DEM layer for the

Sevilleta NWR were delivered from the NASA CRSP Scientific Data Buy Program. These high quality, high resolution radar/DEM data are the basis for generating additional derived products, such as aspect, slope, contour lines, stream drainages and basins, hillshaded and 3-d perspective views. The DEM and derived data layers will be used for site characterization, image stratification, terrain visualization, water-balance and ecosystem modeling efforts, to name just a few.

Both low altitude (4 m resolution) and high altitude (20 m resolution) AVIRIS image data were collected over the Sevilleta NWR in fall 2000 and spring 2001. The AVIRIS data for the Sevilleta LTER is currently being warehoused at the San Diego Supercomputer Center (SDSC) data mass storage device and is accessible via a SRB web interface. The web interface is being redesigned for greater convenience and more specific archive extraction tools, and should be online within the next year; this is being coordinated by John Vande Castle of the LTER Network Office in Albuquerque, and Tony Fountain of the LTER Network Office at SDSC. The 2000-2001 year data are currently being preprocessed by NASA JPL.

Thirteen additional Landsat 7 TM images were purchased from the USGS EROS Data Center (EDC) for the period 2000-2001. This brings the Sevilleta LTER TM archive to a total of 41 scenes. These 13 scenes are in various stages of preprocessing and data archival, and will soon be available on the Sevilleta web site. A loose consortium of investigators at various institutions and agencies in NM, CO, and MD has been formed to coordinate the purchase and sharing of Landsat TM data among the participants. Reduced costs and greater data availability are benefits to all participating investigators, and may result in the Sevilleta LTER obtaining at least one TM scene for every month of the growing season.

Twenty-six AVHRR Bi-weekly composited scenes for the conterminous U.S. were purchased from the USGS EDC for the year 2000. This brings the Sevilleta LTER AVHRR archive to a total of added 276 scenes. These 26 scenes are also in various stages of preprocessing and data archival, and will soon be available on the Sevilleta web site.

Low-level aerial photos were taken of a large portion of east side grasslands of the Sevilleta NWR during August, 2001. These photos will be used for studies of the recent 1400 acre wildfire on MacKenzie Flats, as well as the vegetation patch and pattern studies undertaken this past summer.

The Sevilleta LTER continued the collection of 15-minute interval NASA AERONET Sun Photometry data for studies in atmospheric science and atmospheric correction of remote-sensing data.

Online GIS index maps were built for the 1998 1 m resolution ADAR imagery, and for the 1993 low altitude aerial photography mission over the Sevilleta NWR. Viewing, query, and data status tools are available via ArcView project and web interfaces.

Extensive GPS mapping campaigns were undertaken to maps and generate GIS layers for patch, pattern, woodland seed production, and wildfire studies. Included in this were campaigns to map small to large patches of creosote shrubs, and blue and black grama grasses, on the MacKenzie Flats area of the Sevilleta east side; mapping of individual pinyon and juniper trees within stands at the Savanna and Cerro Montosa sites in the Los Pinos mountains; and mapping the 1400 acre July 2001 wildfire in the MacKenzie Flats area.

GIS specialist Greg Shore initiated a study of the use of 30 m resolution Landsat TM spectral vegetation indices for plant biomass and NPP estimation on the grasslands of the Sevilleta NWR. Mr. Shore generated preliminary regression equations and seasonal/annual GIS maps of aboveground biomass/NPP for a two year period. Refinement and validation of study results is planned, with the hope of generating historical and current maps of seasonal and annual biomass/NPP.

The LTER continued support of the USDA-ARS Hydrology Lab remote-sensing based cross-site LTER studies of energy and water dynamics on the Sevilleta NWR. Ground and airborne acquisitions of multi-spectral, thermal, radiometric, and LAI data were collected in the fall 2000 and the spring 2001.

Mr. Shore also initiated a remote-sensing based study to generate 1 m to 4 m high resolution vegetation maps of the MacKenzie Flats area of the Sevilleta NWR. Traditional supervised classification methods of multi-spectral ADAR and IKONOS imagery will be employed as well as spectral unmixing analysis of 4 m AVIRIS hyperspectral data. Analysis of radiometric calibration data collected during the 1998 ADAR acquisition has been initiated, and field spectra data has been collected to perform classification and unmixing analysis on IKONOS and AVIRIS data. ASD full-range (0.4-2.5 microns) and ASD VNIR (0.4-1.1 microns) field spectrometers are being employed for field measurements. The VNIR field spectrometer was cooperatively purchased by the Sevilleta LTER and the UNM Bosque ET groups for use in this and other RS projects.

The Sevilleta data management staff continued maintenance and upgrading of ESRI ArcInfo/ArcView and ERDAS Imagine software, providing tools to Sevilleta LTER and collaborative PI's for GIS and remote-sensing data analysis. They also installed new high-end SUN Enterprise 450 server to replace an aging and underpowered server for the Sevilleta Information Management System. The new server offers significantly greater disk storage space for the relatively large remote-sensing and GIS databases.

III. Contributions of the Sevilleta LTER Program to the science of ecology.

As detailed in the activities and findings section of this report, the Sevilleta LTER Program has contributed to knowledge of patterns and processes of plants, animals and nutrient cycles along biome transition zones, and particularly across the ectones of the common ecosystems of the Southwest. The Program’s research publications have examined the role of climate dynamics as drivers of large- and small-scale disturbances, and documented the dynamics of plant and animal populations in response to these

disturbances. Long-term experiments using animal exclosures, rain-out shelters, and nutrient additions are contributing knowledge to the roles of these factors in the structure and functioning of southwestern grassland, desert and woodland ecosystems.

IV. Contributions of the Sevilleta LTER Program to other disciplines.

Sevilleta LTER researchers have contributed to the following disciplines:

(1) Participation in the NASA sun-photometer network assists with calibration of satellite images from atmospheric distortions;

(2) Measurement of precipitation across large areas on the Sevilleta is helping to calibrate new weather radars (NEXRAD) for meteorological applications;

(3) Ecological data of rodent populations and environmental conditions are assisting public health researchers in understanding epidemiological phenomena in zoonotic disease outbreaks.

V. Contributions of the Sevilleta LTER Program to Human Resource development.

The Sevilleta LTER has sponsored three formal programs in research training and education, in addition to including graduate and undergraduate students in ongoing LTER research. The three programs are the Research Experiences for Undergraduates (REU) program (including both Site REU and Supplement REU students), the Undergraduate Mentorships in Environmental Biology (UMEB) program (just refunded for 2001-2005), and the Schoolyard LTER program.

In the summer of 1999, we started our renewed REU Site Program (P.I.'s Robert Parmenter and James Gosz) at the Sevilleta; the major emphasis of this program is to related biodiversity to ecosystem NPP in various ecosystem types across the Sevilleta NWR. In addition, beginning this fall semester (September, 2001), our renewed UMEB Program will continue under the direction of Robert Parmenter and William Gannon. As in prior years, the goals of these programs are to (1) instruct undergraduates in the principles of scientific research, (2) expose the students to a wide variety of ecological research techniques and career opportunities, (3) facilitate individual student research projects, and (4) encourage students to continue their scientific education in upper-division courses and graduate school. To accomplish these goals, the programs include (1) orientation meetings and a seminar series devoted to the variety of scientific opportunities in ecological research at the Sevilleta, (2) faculty-student one-on-one instruction of hypothesis development and research protocols in ongoing Sevilleta LTER projects, (3) field and laboratory experiences in sampling and data collection, (4) implementation of individual student research projects, carried out under the guidance of student-selected faculty members, and (5) preparation and submission of project manuscripts to scientific journals. These activities integrate all theoretical and technical aspects of the LTER and promote a holistic approach to large-scale ecological studies.

The Sevilleta Schoolyard LTER program is directed by Co-P.I. Cliff Crawford, and is entitled, "Bosque Ecosystem Monitoring Program/ Sevilleta LTER Schoolyard Program."

This program deals with the ecology of the riparian forest ("bosque" in Spanish) along the Rio Grande in New Mexico, and includes students from a number of schools. The Middle Rio Grande and its riparian forest (bosque) have undergone immense human induced alteration in the past 500 years. The start of a comprehensive and inclusive effort to monitor long-term ecological change in the latter is being made by the BEMP/Schoolyard LTER program.

BEMP/Schoolyard LTER continued to function successfully during the past year. Its Bosque Internship course averaged 10 student interns in each of UNM's fall, spring, and summer semesters. While learning the basics of bosque ecosystem ecology, interns worked with K-12 student "volunteers" and their teacher "site representatives" during simultaneous monthly monitoring sessions at the program's seven sites, located between Santa Ana Pueblo and Lemitar. BEMP's Third Annual Fall Teacher Workshop and Spring Student Congress were both held at Bosque School, an important partner of the program. Newspaper and newsletter articles as well as a variety of presentations by program participants continued to publicize its activities.

BEMP/Schoolyard LTER's mission is to integrate science and outreach so as to make long-term bosque ecosystem monitoring data available to resource managers, policy makers, and the public. In August 2001 it will publish and distribute a report of its first four years of operation. To date, it has involved 11 regular site representatives plus assistant teachers, between 20 and 40 parents and older volunteers, over 1,000 students from public, private, and home schools, five experienced biologists employed for certain tasks, and 73 Bosque Internship students.

The report first summarizes BEMP/Schoolyard outreach since 1997, then presents analyses of monitoring data collected following each site's establishment. The report shows that sites range considerably in their hydrological connectivity with the Rio Grande, as reflected in differences among average groundwater depths and seasonal groundwater fluctuations. Each site's seasonal and annual productivity of native and introduced woody plant productivity (measured using monthly litterfall trap collections) is also comparatively unique. Other physical and biotic parameters (e.g., monthly precipitation recorded beneath cottonwood trees and in the open, size distribution and number of cottonwoods, total plant cover, indicator surface arthropod activity) also differ appreciably among sites. Projected annual supplements to the report will enable resource managers to track the dynamics of these variables. The report will appear on the Sevilleta web page as soon as it is completed this fall.

VI. Contributions of the Sevilleta LTER Program to Educational and Research Resources.

Educational Resources. The Sevilleta LTER Program is collaborating with the BBC to create a "virtual field trip" series on DVD for college students. The program will be

interactive, and allow students to investigate field ecology studies and learn about different ecosystems in the United Kingdom and the American Southwest. Filming for this project is scheduled for late August, 2001, at the Sevilleta refuge. Final production should be completed in early 2002.

Research Resources. The Sevilleta LTER Program is the major research group using the University of New Mexico's Sevilleta Research Field Station. The LTER program continues to provide the field station with administrative support (Director Parmenter's salary, and salary for the Administrative Assistant, Mrs. Joslyn Garcia), as well as LTER staff to compile data from all weather stations, GIS and ongoing research projects. The field station then provides field support to a large number of scientists and students studying the ecology, geology, anthropology, and climatology of the Middle Rio Grande Valley.

During 2000-2001, Parmenter and Gosz were awarded an NSF grant from the Field Stations and Marine Laboratories Program to increase laboratory space and construct a new building for the preservation and storage of dried/preserved samples of soils, plant materials, and arthropods. These improvements will result in a net gain of 1,500 square feet of laboratory space, and nearly double the station's available storage and shop space. The net result will be more usable work space for visiting researchers.

VII. Contributions of the Sevilleta LTER Program beyond science.

The Sevilleta LTER Program has contributed to three major arenas of public concern:

(1) The hantavirus research continues to provide information to public health officials on the abundances of rodents in New Mexico in relation to environmental conditions; these data are part of an "early warning" system for alerting the general public to increased dangers of hantavirus transmission (as was done following the El Nino of 1999, when rodent populations expanded rapidly).

(2) Results of the LTER's fire ecology data sets have been used by the U.S. Fish and Wildlife Service in developing the new fire plan for the Sevilleta National Wildlife Refuge. These LTER data showed that grasslands recover quickly from natural fires, and that fire could be used as a management tool in reducing shrub encroachment into the grasslands. The FWS managers are now proposing to let natural fires burn in the grasslands, and will initiated a series of controlled burns to make up for past management practices of stopping all fires.

(3) The results of tree ring studies by Dr. Tom Swetnam and Dr. Julio Betancourt, coupled with analyses of the data by Dr. Bruce Milne, have shown that central New Mexico experiences major droughts on an average of every 58 years. As it has been about 50 years since the last drought (post-WWII), New Mexico is due for the next one. This information has been transmitted to public officials in New Mexico, and this result is being incorporated into water use planning for Albuquerque and the Middle Rio Grande Basin.

VIII. Cross-site activities

Our cross-site studies include a comparison of plant species diversity and vegetation structure at three LTER sites in the US (SGS, SEV, JRN) with three arid grassland sites in Hungary. We are expanding our cross-site studies to include additional Chihuahuan desert sites (Big Bend National Park, Armendaris Ranch, Ft Bliss) and shortgrass steppe sites (Kiowa and Comanche National parks). These new research efforts are described under 2. New grants related to the LTER (see below).

As part of our previous NSF grant, we compared patterns in plant species diversity, productivity and climate for the three LTER sites located along a north-south gradient within adjacent grassland biomes (shortgrass steppe, Chihuahuan desert) and their transition zone (Hochstrasser et al. in press). We tested two hypotheses: (1) local or alpha diversity is related to climate or plant productivity, and (2) spatial heterogeneity or beta diversity and total site-scale richness are highest at the transition zone. Most measures of precipitation and moisture at the SEV were more similar to the JRN than to the SGS. Temperature increased along a north-south gradient. Perennial species richness at the local and site scales as well as spatial heterogeneity were related to a long-term aridity gradient where richness was highest at the semiarid SGS site compared with the more arid Chihuahuan desert (JRN) and biome transition sites (SEV). Richness of perennials was highest at the SGS as a result of large numbers of C_3 perennial species. Long-term data showed that local-scale richness of annuals was related to precipitation in the year of sampling. Site-level richness of annuals was similarly high at the two most arid sites, mostly as a result of C_4 annual grasses and forbs

We are also conducting cross-site studies of the role of fire in Chihuahuan desert ecosystems (Drewa et al. in press). We conducted a multi-scale sampling of blue and black grama patches at the SEV in July 1998 following a lightning-ignited fire in Bootleg canyon. Our hypothesis was that different patch types would respond differently to fire. We also sampled unburned patches within the larger, burned matrix and expected that these patches would be areas of nutrient and soil accumulation through time that would positively affect vegetation responses. These patches will be resampled in August 2001. A similar sampling scheme was used before and after a controlled burn of 1000 acres at the Jornada Experimental Range in June 1999. At the JRN-LTER, we focused on the response of black grama and honey mesquite following fire. Combining results across sites will allow us to examine the effects of precipitation and temperature as well as grazing or exclusion on recovery of perennial grasses following fire.

Co-PI Kristin Vanderbilt (also the LTER Information Manager) led or participated in three international outreach activities designed to educate ILTER scientists about ecological data management and strengthen ties between the LTER and ILTER Networks. Dr. Vanderbilt organized and co-taught a five-day ILTER Information Management workshop in Vacratot, Hungary from October 30-November 3, 2000 for twelve scientists from Central and Eastern European countries, including the Czech Republic, Poland, Romania, Hungary, and Slovakia. Topics covered included database design, metadata, data archives, QA/QC and tools for connecting databases to the

internet. The web-site designed and maintained by participants of this workshop is: http://www.krnap.cz/lter/workshop.html. Funding for travel of the European scientists was supplied by GTOS (Global Terrestrial Observing System), a United Nations program. As a result of this workshop, ILTER sites in the CEE ILTER region have begun to make their data accessible on the WWW. Building on the success of the Hungarian workshop, Dr. Vanderbilt co-taught a similar ILTER Information Management workshop in Ulaanbaatar, Mongolia from July 8-10, 2001 for participants from the East-Asian Regional ILTER: Mongolia, Taiwan, China, and Thailand. The Mongolian participants of this workshop have since formed the "Organizing Group of Database Managers in the Mongolian Academy of Sciences" which will provide leadership in database development to scientists at Mongolian universities and government institutes. Funding for this workshop came from an NSF grant to San Diego Supercomputer Center. Finally, the Sevilleta Field Station hosted a two-week Eco-Informatics workshop for Israeli and Palestinian scientists in October 2000, during which Dr. Vanderbilt lectured and led laboratory exercises in QA/QC. A follow-up workshop for other ILTER scientists from Israel and Palestine is planned for September 9-15, 2001 in Germany.

IX. Additional grants in collaboration with the Sevilleta LTER Program:

Several new 2001 projects funded by external sources will contribute to the Sevilleta LTER research goals.

1. National Science Foundation, LTER Cross-site program, "Regional variation in direct and indirect influences of animals on Chihuahuan desert grasslands". $200,000. 2001-2004. D.P.C. Peters, PI. Brandon Bestelmeyer and Debra Peters received funding from the NSF Cross-site initiative to study the role of small animals on grass recruitment across a climatic gradient that includes three sites in the Chihuahuan desert. The sites range from the Sevilleta National Wildlife Refuge LTER site in central New Mexico to the Jornada Basin and Range LTER in southern New Mexico to Big Bend National Park in southwestern Texas. This project started in 2000, and will continue for 3 years. Efforts to date have focused on site selection and construction and installation of cages suitable for excluding small animals ranging in size from grasshoppers to kangaroo rats and rabbits. Three locations were selected at each site that consist of an ecotone between black grama grassland and an alternative dominant species, either creosotebush (SEV), honey mesquite (JRN) or chinograma (Big Bend). Cages are being installed this summer (2001), and response variables will be measured for 2 years. One graduate student in the biology department at NMSU (Andrew Rayburn), one technician (Jennifer Johnson) and one postdoc (Tamara Hochstrasser) are working on this project.

2. National Science Foundation, International Programs, "US-Hungary grassland comparisons: Biodiversity, disturbance, and landscape mosaics". D. P.C. Peters and J. R. Gosz, PIs. 9/1/01-8/31/04. $150,000. Debra Peters and Jim Gosz received funding from NSF Ecological Studies to continue collaborations with a group of ecologists in Hungary headed by Dr. Edit Kovacs Lang, Institute of Ecology and Botany, HAS, Vacratot, Hungary. This project will examine the role of small disturbances in generating

landscape- and regional-scale patterns in species diversity. Experiments will be conducted at three LTER sites from the shortgrass steppe in northern Colorado (SGS) to the SEV and JRN in New Mexico. Additional sites will also be studied that occur between the LTER sites. These sites include the Comanche National Grasslands in southeastern Colorado, the Kiowa National Grasslands in northeastern New Mexico, and the Armendaris ranch in southcentral New Mexico. Similar experiments will be conducted at three sites located along a climatic gradient in Hungary. In addition to the experiments, a major focus of this project will be to enhance the potential for future collaborative projects and to increase interactions between US and Hungarian researchers. We will meet these goals through student and junior investigators exchanges between countries. This project will begin in September (2001) and will continue for 3 years. There will be one graduate student in the biology department at NMSU working on the project (Kathi Sheehan).

3. U.S. Army Construction Engineering Research Lab, "Prediction of future plant community dynamics for military installations using simulation modeling" D.P.C. Peters and K. Havstad, PIs. 6/26/01-7/31/02. $99,036. Debra Peters and Kris Havstad (USDA-ARS) recently received funding from the US Army to extend the ECOTONE simulation model of vegetation and soil water dynamics to additional plant communities in the Chihuahuan desert. ECOTONE was originally parameterized for blue grama, black grama, and creosotebush communities at the SEV. This funding will allow us the opportunity to parameterize the model for other important communities, such as honey mesquite shrublands, tarbush shrublands, and tobosa grasslands as well as various grassland-shrubland associations. This project started June 26, 2001. Funding is at 1 year increments, although we expect a long-term collaboration with CERL personnel. This project will support one postdoc and one programmer.

4. Environmental Protection Agency, "Carbon sequestration potential of Southwestern rangelands" Monger, H.C., D.P.C. Peters, J.E. Herrick, and J.T. Harrington, PIs. 8/1/01-7/31/02. $623,600. Curtis Monger (NMSU), Debra Peters, Jeff Herrick (USDA-ARS) and John Harrington (NMSU) recently received funding from EPA to conduct studies related to carbon sequestration in New Mexico. This project will examine and quantify spatial patterns in carbon dynamics at the Jornada as well as at the SEV-LTER and at a site in northern New Mexico in pinyon-juniper woodlands. Field inventories will be combined with simulation modeling in order to rate management options as to their potential to lead to changes in carbon sequestration in different parts of the landscape. This project will start late summer (2001) and is funded in 1 year increments. The project will provide equipment to analyze soil samples (C-N mass spectrometer) and will support laboratory, field and modeling personnel (2 technicians, 1 postdoc, 1 programmer).

5. Bruce Milne, Dave Bader, Will Pockman and Carla Restrepo, NSF-Ecosystems Panel, "Self-organization of semi-arid landscapes: Tests of optimality principles, $674,911, Status: Funded 1/1/2000 – 12/31/2002. This study examines topographic variables (slope, aspect, elevation) in pinyon-juniper woodlands at the Sevilleta to elaborate on details of AET/PET water-balance and energy relationships in determining the population dynamics and distributions of trees in this semi-arid environment.

6. Eric E. Small. Invasion of semiarid grasslands by shrubs – the influence on soil moisture, NSF Hydrology; $170,000; April 2001 – March 2004. This grant examines water balance aspects of creosotebush at the ecotone between Chihuahuan Desert shrub vegetation and shortgrass steppe vegetation.

7. Ana Davidson. The comparative and interactive effects of two keystone rodent species, black-tailed prairie dogs and banner-tailed kangaroo rats, on desert grassland communities in northern Mexico. T & E, Inc., $2,500, May 2001 – May 2003. This grant assists LTER graduate student Ana Davidson in her dissertation research on the Sevilleta.

8. Robert Parmenter and William Gannon. Undergraduate Mentorships in Environmental Biology (UMEB): Undergraduate Career Enhancement and Training in Ecological Studies in New Mexico. NSF, $400,000, 9/1/01-8/31/05. This grant renewed the UMEB program at the Sevilleta (originated in 1993); please see details in the Contributions to Human Resources Development Section of this report.

9. Robert Parmenter and James Gosz. The Sevilleta Research Field Station: Development of a Long-Term Sample Processing Laboratory and Storage Facility.

NSF, $79,562, 10/1/01-9/30/03. This grant, from the Field Stations and Marine Laboratories Program, will allow expansion of laboratory facilities at the field station, and will construct a new storage facility for soil, plant and arthropod samples.

10. M.F. Allen and K.K. Treseder. Isotope and genetic studies to assess microbial carbon storage in natural and human altered environments. Lawrence Livermore National Laboratory. $12,510 (2000-2001).

11. M. F. Allen. Biocomplexity: Common mycorrhizal networksActive or Passive Channels? Interacting roles of mycorrhizal fungi, soil resources, and plants in carbon and nutrient transfers. NSF, $866,286. 1999-2004.

12. M. F. Allen. Collaborative proposal: Factors regulating below-ground carbon allocation in terrestrial ecosystems: A cross-site experiment. NSF, $287,089. 1997-2001.

X. Sevilleta LTER Publications.

Please see the Sevilleta LTER web page for a current listing of all publications