Supplement to the Jornada Basin LTER Program 2001: REU, Schoolyard LTER, and Improvement of Spatial Metadata

The Jornada Basin Long-Term Ecological Program recently began its fourth full funding cycle. Administration of the program has returned to New Mexico State University in 2000 after a number of years of leadership by Duke University scientists. Our focus on desertification processes in the Chihuahuan region is increasingly relevant to human concerns in the area, as the population grows, land uses change, and pressures on natural resources intensify.

Here we request supplemental funding for four major activities for the coming year:

- support for three participants in the Research Experience for Undergraduates (REU) program,
- continued development of our Schoolyard LTER program,
- the development of a major new interface for our GIS and spatial metadata, to better take advantage of the long history and rich legacy of research in the Jornada Basin,
- and the enhancement of our cross-site work in the area of consumer populations and impacts.

Each of these efforts is described separately. Budget justifications for the three supplemental proposals (REU, SLTER, and site supplement) are presented together in the appropriate section, and a total budget for all activities is presented on the NSF budget page.

I. REU Supplement: focus on plant community dynamics

Undergraduate research assistants and REU supplements have been an important component of the Jornada Basin's LTER activities over the past two funding cycles. These small investments have yielded large results both in terms of research activities and in terms of providing support to new investigators, as well as in the primary objective of providing research training and experience to young prospective scientists. While our REU students have been drawn from the student populations of the home institutions of all our investigators (including Duke, Dartmouth, and so on), many have come from the main campus of New Mexico State University. NMSU is categorized as a minority institution and a Hispanic-serving institution, based on the demographic characteristics of the student body (virtually 50 % under-represented minorities, largely Hispanic and Native American). It plays an important role in the recruitment of Hispanics and Native Americans to the agricultural, biomedical, engineering, and other scientific and technical fields.

We propose this year to recruit a set of three undergraduate REU students from NMSU, to work together on a set of three related projects under the joint supervision of Debra Peters and Laura Huenneke. The linking of three related projects will facilitate shared field efforts and provide mutual support and group mentoring (elements demonstrated as important in increasing the interest and commitment of prospective researchers). Recruitment of students from the home institution will allow activities and student support to continue into the following academic year, which is important both for the impact on the students and for the successful resolution of the projects described here.

The overall theme of our projects is a focus on plant community dynamics in the variable and responsive ecosystems of the northern Chihuahuan desert. Our landscape has seen dramatic changes in ecosystem structure in many places, with shrublands of several different types replacing previous perennial grasslands in some but not all areas. We propose a set of three projects, each examining one aspect of the dynamics of this landscape mosaic. Each student will have the primary responsibility for one of these projects, though they will be able to pool resources and field efforts to make effective progress. Students will be recruited primarily from the main campus of NMSU, through established successful mechanisms (the Student Employment Office, the Biology Department's email listserv for majors, and offices supporting minority students on campus, such as the NSF-funded Alliance for Minority Participation, the NIH-supported MBRS/RISE program, and the ethnic programs offices). We request funds only for direct student support; materials, supplies, and field travel expenses will be paid from non-REU funds. We anticipate that students will be able to make sufficient progress on their projects to make presentations at the NMSU Biology Department's annual research symposium (normally in March of each year). We will also seek opportunities to have the students present their work at a major regional or national scientific meeting (AAAS-SWARM, ESA, etc.).

One undergraduate student is requested to assist in the location and characterization of remnant grass patches located at the JRN LTER. These patches of black grama (*Bouteloua eriopoda*) are particularly interesting since they have not been treated to minimize or halt the invasion of shrubs, yet the patches have remained dominated by perennial grasses. An understanding of the key processes and environmental conditions allowing black grama to maintain

dominance in these isolated patches will provide insight into remediation efforts on other parts of the Jornada. A first step in providing a better understanding of these patches is to accurately map them and characterize their vegetation and soil properties. The student will locate the GPS coordinates of these patches, and sample the vegetation and soils of the patch and surrounding vegetation. The student would be trained in using a GPS unit in the field as well as entering and using map coordinates in a GIS in order to overlay patch locations with existing data layers. The student would also receive training in sampling vegetation and soils.

A second undergraduate student is requested to assist in the location and characterization of black grama plants available as seed sources for an experiment established in 1939. Within a >1 ha area dominated by creosotebush, all shrubs have been removed every 5-6 years and lagomorph exclusion treatments were also applied. Very few black grama plants occurred within the plot at the start of the study, and significant recovery of black grama was not recorded until 1989. Recovery has been very slow with 1% average basal cover currently found within the plot compared to 7-15% basal cover in black grama-dominated areas. We hypothesize that the initial recovery was constrained by seed availability as well as the low soil water available for seedling establishment on these degraded soils. Subsequent recovery has also been limited by soil water constraints on stolon establishment. We expect that seeds became available to the plot primarily through dispersal by wind followed by seed germination and seedling establishment in suitable microsites. We would like to test our hypotheses by determining the distance and direction of each black grama plant located within 2 km of the plot to the edge of the plot. Wind dispersal models can then be used to determine if wind alone can account for the recovery patterns or if other vectors of dispersal are also important, such as water, rodents and ants. The undergraduate will determine the map coordinates of all black grama plants in the vicinity of the exclosure, and calculate the distance from each plant to the exclosure. Plant coordinates will be overlain with digital elevation models and soils maps to estimate probabilities of dispersal through wind and water. The student would be trained in using a GPS unit in the field as well as overlaying map coordinates with existing datalayers to analyze the plant location data. A dispersal model will be developed that accounts for the distance, topography, and wind speed and direction in calculating probabilities of seed dispersal.

The third undergraduate student will focus on shrub seedling recruitment processes as another aspect of plant community dynamics. Shrub seedlings (primarily of creosotebush and of mesquite) are encountered at least occasionally in several of our long-term study sites: the shrubland and grassland sites of our network of NPP plots, a creosote bush stand that has been the site of demographic and experimental work on *Larrea*, and the plant diversity experiment where species and functional groups have been removed from a diverse shrubland. Seedling establishment is rather rare, though, and in many years seedlings are so sparse as to prevent any meaningful characterization of their patterns of occurrence or estimates of establishment rates. The summer and fall of 2000, however, saw the establishment of moderate numbers of seedlings in several areas, and the locations of many of these were marked or noted. The REU student will relocate those seedlings and examine other plots and datasets (e.g., the fall 2000 data from the NPP quadrats) for additional seedlings. These seedlings will be recensused and the nature of the patch in which they occur will be characterized (grass cover, shrub cover, other vegetative cover, bare soil). Long-term NPP datasets will be searched to identify the nature of quadrats within which seedlings appeared (and either survived or failed to survive) over the past 12 years. Logistic regression (failure analysis) and other demographic approaches will be used to estimate the rate of shrub establishment over the long term. These data will be used to test hypotheses about the dependence of shrub seedling recruitment on local patch conditions.

II. Schoolyard LTER program: partnerships with schools and teachers

The Jornada Basin Schoolyard LTER program is a partnership of the LTER program with a non-profit group, the Chihuahuan Desert Nature Park, facilitating the established educational outreach programs of the USDA Jornada Experimental Range. During the first year of Schoolyard supplement funding, the Jornada Basin LTER created pilot Schoolyard LTER (SLTER) sites at one local elementary school and one high school. During the second year, we added a third site at a middle school and expanded the program of CDNP support for student visits to the field site and classroom activities. During the third year of funding, we added two new schoolyard sites, created a new experiment, began an undergraduate intern program, and coordinated the SLTER program with an NSF-funded teacher-training workshop. We are proposing to use the fourth year of SLTER funding to address the following objectives:

1) Continue support for five existing SLTER sites.

2) Create a Jornada SLTER web site, which will include an online version of the Jornada SLTER Handbook and web pages from participating schools.
3) Coordinate and conduct a one-day SLTER workshop for participating SLTER teachers.
4) Conduct a two-week summer workshop on desert ecology and hands-on science for prospective SLTER site teachers.
5) Add at least one additional middle school to the Jornada SLTER program.

We have budgeted for supplies needed to set up and maintain SLTER sites and costs associated with running the one-day teacher workshop and the two-week summer workshop.

Background and Justification

One-third of Earth's land surface is classified as arid land, and rapid population growth is occurring throughout much of this land in North America. For example, since 1990 the populations of Doña Ana County, New Mexico and El Paso County, Texas have increased by 25% and 19%, respectively. Such rapid growth translates to equally rapid human modification of the arid ecosystems. However, feedbacks between urban environments and the surrounding desert ecosystems are poorly understood by the general public, leading to frequent misinterpretations of the causes and consequences of human activities.

Scientists associated with the Jornada LTER (especially scientists with the USDA/ARS Jornada Experimental Range and New Mexico State University) have been working on informal science education programs for many years. The quality of these programs rapidly produced a situation where demand for field trips and other student/scientist interactions became so high that scientists were unable to fulfill all requests.

In order to ameliorate the situation, Jornada LTER scientists formed a collaboration with a local educational nonprofit organization, the Chihuahuan Desert Nature Park. As part of this collaboration, LTER scientists (1) provide the scientific basis for curriculum, (2) guide students on field trips, (3) assist students with data collection at their SLTER sites, and (4) participate in teacher workshops. Chihuahuan Desert Nature Park staff (1) handle scheduling and other administrative tasks, (2) ensure that all curriculum materials are age-appropriate, and (3) work with students in all educational programs. The benefits of this collaborative relationship cannot be overemphasized. Over 7,000 K-12 students and 300 teachers each year are served by the joint efforts of the Jornada LTER, the Jornada Experimental Range, and the Chihuahuan Desert Nature Park.

The Jornada SLTER program focuses on setting up long-term plots on land adjacent to schools. Students use these plots to conduct studies that parallel Jornada LTER research. Teachers and students participate in one or more of the following studies:

1) Vegetation monitoring: students measure plant composition and cover.
2) Weather monitoring: students measure temperature, precipitation, wind speed and wind direction.
3) Disturbance experiment: students measure soil and vegetation properties to monitor resistance to and recovery from disturbance (human trampling).

SLTER participants also take advantage of field trips to the Jornada Experimental Range and Chihuahuan Desert Nature Park classroom presentations on various aspects of desert ecology.

During 1999 and 2000, the majority of the Jornada SLTER supplement was used to pay a half-time coordinator for the program. This use of funds has resulted in a strong program framework, including well-designed studies, strong support for participating teachers and a rapidly increasing number of participating schools. As a direct result of this strong framework, we secured outside funding for the coordinator position. We are therefore now in a position to use SLTER funds for more direct support of teachers and students.

Progress

Sustainability: The relationship between the Jornada Experimental Range, New Mexico State University, and the Chihuahuan Desert Nature Park produces many benefits. This model may be of interest to other LTER sites grappling with increasing demand for K-12 education programs.

SLTER Sites: During 2000, negotiations were completed for the addition of two new schools to the Jornada SLTER

program. Both of these schools (Davenport Elementary in Canutillo, Texas and Sunrise Elementary in Las Cruces, New Mexico) serve primarily low-income, minority populations. In response to teachers' requests for experiments in addition to monitoring studies, a new experiment was developed. Through this experiment, students participate in all aspects of the scientific process as they investigate the short-term and long-term effects of disturbance (human trampling) on the resistance and recovery of a desert site. The experiment and other student activities are related to the New Mexico state content standards and benchmarks for science curriculum; these standards emphasize student experiences in science as inquiry and in direct work with quantitative results and concepts.

Field Trips and Class Visits: Over 7000 K-12 students and 300 teachers participated in classroom presentations, field trips, SLTER site investigations, and other educational activities during 2000.

Coordination With Other Education Efforts: The First Step teacher-training program was a three-year program funded jointly by NSF and the USDA Agricultural Research Service. By coordinating this program, we were able to provide the background information on desert ecology and research protocols to teachers interested in the SLTER program. The two new SLTER schools are the result of teachers learning about the SLTER program during First Step. Funding for the First Step program has now expired, leading us to request SLTER funding for a shortened version of the workshop (Objective 4, below).

Involvement of NMSU undergraduate students: An internship program for NMSU Biology undergraduates was started in early 2000. So far, this program has involved two undergraduates who assisted with K-12 science education programs and material development.

Current Year Objectives and Project Description

1) *Continue support for five existing SLTER sites*. LTER scientists and Chihuahuan Desert Nature Park staff will continue to assist teachers and students with plot and weather station maintenance, data collection and data presentation. We expect the one-day teacher workshop (Objective 3, below) will give additional support and ideas to participating teachers.

2) *Create a Jornada SLTER web site, which will include an online version of the Jornada SLTER Handbook and web pages from participating schools*. Chihuahuan Desert Nature Park volunteers will work with staff educators and scientists to create a web site for the Jornada SLTER program. The web site will contain a description of the program, protocols for data collection and pages for each school to showcase its results and conclusions.

3) *Coordinate and conduct a one-day SLTER workshop for participating SLTER teachers*. We have learned from three years of experience with the SLTER program that SLTER teachers require considerable support, especially in their first year of participation. We have already reached the point where demand has outstripped our limited resources. In order to expand the program, we are therefore proposing an annual teacher workshop for at least one teacher from each SLTER site. These workshops are intended to enhance communication between schoolyard sites and allow teachers new to the program to learn from the experience of those teachers who have participated for several years.

4) *Conduct a two-week summer workshop on desert ecology and hands-on science for prospective SLTER site teachers*. Our participation in an NSF- and Agricultural Research Service-funded teacher-training workshop (First Step) has benefited our program. Teachers leave the workshop with a better understanding of desert ecology, an increased appreciation of the importance of doing hands-on science with their students, and an awareness of the considerable scientific resources available in this area (including the Jornada Basin LTER). First Step was funded for three years, ending with the summer 2000 workshop. We are proposing to use some SLTER funding to hold a modified version of this summer workshop for teachers, using our experience conducting the workshops over the last three years.

5) *Add at least one more middle school to the Jornada SLTER program*. The Jornada SLTER program is especially relevant to the current needs, standards, and curriculum of middle schools in this region. We therefore look forward to increasing the number of participating middle schools. We will use our nonprofit partner's contacts with local schools to develop a new middle school site.

Anticipated Outcomes

As a result of the creation of the Jornada SLTER website and the completion of the one-day and two-week teacher workshops, we expect the following results:

- SLTER teachers who are comfortable with the background information and protocols necessary to conduct the studies.
- Enhanced communication between participating teachers at different schools, resulting in a true internal support network for teachers.
- An SLTER program that reflects teachers' needs, as communicated to us through the one-day workshop.
- A network of SLTER teachers who can learn from each other's experiences with the program and who can work together to generate new ideas for the improvement of the Jornada SLTER program.

Timetable

June 2001	Recruit teachers for summer workshop. Establish Jornada SLTER web site.
July 2001	Two-week summer workshop. Repair sites and weather stations at existing SLTER sites, as needed.
August 2001	Add new middle school to program – set up site and weather station.
September 2001	Conduct one-day SLTER teacher workshop.
Sept.-Dec. 2001	Participating schools visit Jornada for field trip. Participating schools do fall data collection.
Jan. – April 2002	Participating schools do spring data collection and share data.
May 2002	Final presentations.

III. Site Supplement: Development of a GIS/spatial meta-data application, and support for our cross-site consumer work

Accessibility of spatially-explicit metadata. A dynamic, interactive, and queryable mapping (and querying) Intranet and Internet application would be a powerful tool for JRN information managers, researchers, and visitors. We propose to allocate the majority of a supplement award, matched by some internally available funds, to develop an ArcIMS application to serve as the interface between the research and education communities and the rich legacy of Jornada Basin data resident in our GIS and databases. Some Intranet uses of the application would be to facilitate research site selection and approval as well as to automate the storage and retrieval of restricted and unrestricted spatial and non-spatial data and meta-data into and from the JRN information management system. It should also assist in land management decisions and eco-health evaluations, as well as monitoring of spatial and temporal vegetation changes. The mapping application would have to be secure and scalable. A publicly accessible Internet area of the mapping application would allow the graphical display and querying of unrestricted spatial and non-spatial data and meta-data by researchers, land managers, other LTER sites, administrators, K-12 schools, and the general public. Reviews from our last site visit and most recent renewal proposal confirm that while we have made great progress in capturing the 85 years of research results from the Jornada, our information management system does not fully do justice to that legacy nor provide data users with the spatial overview and accessibility needed.

Selection of spatial and non-spatial data and meta-data to be part of the Internet, or public, mapping application would have to be determined by coordination between JRN information managers and PIs. Other issues that may affect the choice of data and meta-data to include in the Internet part of the mapping application include network performance and server load issues, which can be linked to concurrent users accessing the proposed system. The developer should supply information on hardware, software, platforms, or services needed to improve bandwidth and network performance in order to run the mapping application given different ranges of concurrent user loads and types (Internet, Intranet). This information should be detailed enough to allow JRN PIs and information managers to plan

and budget for scaling up the infrastructure needed to support growth in users accessing the mapping application and growth of spatial and non-spatial data and meta-data stored and accessed by the ArcIMS application.

The Jornada LTER site office staff is unable to complete an application development project of this scope without either hiring a qualified temporary ArcIMS developer or outsourcing development to an outside contractor. It has been very difficult for our GIS specialist to fill a part-time GIS Assistant position, given the limited pool of qualified persons in Las Cruces and the limited ability of NMSU to pay adequate salaries. It will be even more difficult to find someone locally (student or otherwise) with the qualifications necessary to produce a final product. Hence we have decided that the Jornada Basin LTER search for a company or individual that would be qualified and submit a bid on project cost.

The funds requested here will initiate the project. Specifically, the supplement will be used to purchase a server to support ArcSDE and MS SQL. These provide the essential hardware/software elements to support the development of the ArcIMS application. We also request support for training for Jornada information staff to enable them to populate ArcSDE with spatial data and meta-data in preparation for the ArcIMS application development and to maintain the application once it is implemented. Funding for the actual development of the ArcIMS application and other hardware and software will come from information management and equipment funds in our current and previous increments and possible collaboration with the USDA ARS Jornada Experimental Range, with whom we share GIS and database management. The supplement funds will furnish a critical base for tying together the resources needed to develop and implement the interface.

Cross-site consumer studies. Cross-site work is exemplified at the Jornada Basin LTER by Dr. Dave Lightfoot, who is a principal investigator at both the Jornada and Sevilleta sites, and who coordinates our consumer population studies. Lightfoot also administers the Small Mammal Exclosure Study, with parallel study areas in Sevilleta, Jornada, and the Mapimi Biosphere Reserve in Durango/Coahuila states, Mexico. While our base funding provides sufficient support for seasonal visits for Lightfoot to the Jornada site, to supervise field sampling efforts, it is highly desirable to support an increased frequency of visits during this first year of our new cycle. Several new aspects of consumer studies (focused on assessing animal roles in herbivory, seed dispersal, and soil disturbance) are being initiated. We are also at a critical stage in coordinating data analysis from the multiple sites in the Small Mammal Exclosure Study and in the comparative arthropod studies being done at SEV and JRN. We therefore request a modest increment of funds to support more frequent travel among sites by investigator Lightfoot.

The final portion of our request is for a high quality dissecting microscope, to be used in the sorting and identification of arthropods from our routine collections. Arthropods constitute a major part of the diversity at Jornada as well as important functional components of our ecosystems; the arthropod pitfalls represent an extremely valuable long-term data set associated with our network of permanent net primary production plots (15 permanent sites, 3 in each of 5 ecosystem types). Unfortunately, the Jornada possesses only old and somewhat limited microscopes for arthropod sorting and identification. We therefore request a small portion of equipment funds to purchase a higher quality dissecting microscope (and to save the eyesight and sanity of those sorting our smaller arthropods). The type of microscope that we need is a stereoscopic zoom dissecting scope, with parallel optics. The magnification required is a zoom range from 15X to 70X. We are hoping to purchase a Nikon SMZ800 series microscope, plus a fiber-optic light source which is necessary for the operation of the scope. The total cost is approximately $2,500.00.