Annual Report for Period: 10/2002 - 10/2003
Submitted on: 09/03/2003
Principal Investigator: Huenneke, Laura F.
Award ID: 0080412
Organization: New Mexico St University
Title:
LTER IV: Jornada Basin: Linkages in Semi-arid Landscapes

Project Participants

Senior Personnel

Name: Huenneke, Laura
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Havstad, Kris
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Peters, Debra
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Monger, Hugh
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Abrahams, Athol
Worked for more than 160 Hours: Yes
Contribution to Project:
Investigator/sub-contractor receiving research and travel support

Name: Gillette, Dale
Worked for more than 160 Hours: Yes
Contribution to Project:
Investigator receiving research and travel support

Name: Gutschick, Vincent
Worked for more than 160 Hours: Yes
Contribution to Project:
Investigator receiving research support

Name: Herrick, Jeffrey
Worked for more than 160 Hours: Yes
Contribution to Project:
Investigator receiving research support

Name: Lightfoot, David
Worked for more than 160 Hours: Yes
Contribution to Project:
Investigator receiving research support

Name: Parsons, Anthony
Worked for more than 160 Hours: Yes
Contribution to Project:

Investigator/sub-contractor receiving research and travel support

Name: Rango, Albert
Worked for more than 160 Hours: Yes
Contribution to Project:
Investigator receiving research and travel support

Name: Schlesinger, William
Worked for more than 160 Hours: Yes
Contribution to Project:
Investigator/sub-contractor receiving research and travel support

Name: Wainwright, John
Worked for more than 160 Hours: Yes
Contribution to Project:
Investigator/sub-contractor receiving research and travel support

Name: Bestelmeyer, Brandon
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Abbott, Laurie
Worked for more than 160 Hours: Yes
Contribution to Project:

Post-doc

Name: Goslee, Sarah
Worked for more than 160 Hours: Yes
Contribution to Project:
Postdoc supported on supplement to explore application of high-resolution satellite imagery

Name: Bestelmeyer, Brandon
Worked for more than 160 Hours: Yes
Contribution to Project:
Supported on LTER funding and associated grant funding

Name: Yao, Jin
Worked for more than 160 Hours: Yes
Contribution to Project:
Postdoc on LTER base funding

Name: Drewa, Paul
Worked for more than 160 Hours: Yes
Contribution to Project:
Postdoc on associated grant.

Name: Mitchell, Katherine
Worked for more than 160 Hours: Yes
Contribution to Project:
Postdoc on associated grant

Name: Hochstrasser, Tamara
Worked for more than 160 Hours: Yes
Contribution to Project:

Postdoc on associated grant

Name: Chopping, Mark
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Gomez-Landesa, Enrique
Worked for more than 160 Hours: Yes
Contribution to Project:

Graduate Student

Name: McGlone, Christopher
Worked for more than 160 Hours: Yes
Contribution to Project:
MS student

Name: Skarsgaard, Amanda
Worked for more than 160 Hours: Yes
Contribution to Project:
MS student

Name: Sheehan, Kathi
Worked for more than 160 Hours: Yes
Contribution to Project:
Ph.D. student on associated grant

Name: Rayburn, Andrew
Worked for more than 160 Hours: Yes
Contribution to Project:
MS student on associated grant

Name: Schmidt, Sebastian
Worked for more than 160 Hours: Yes
Contribution to Project:
Graduate student at Duke University

Name: Perez, Alfonso Serna
Worked for more than 160 Hours: Yes
Contribution to Project:
Ph.D. student on associated grant

Name: Duniway, Mike
Worked for more than 160 Hours: Yes
Contribution to Project:
Ph.D. student on associated grant

Name: Endres, Andres
Worked for more than 160 Hours: Yes
Contribution to Project:
M.A. student

Name: Cunningham, Lisa
Worked for more than 160 Hours: Yes
Contribution to Project:

Ph.D student

Name: Mueller, Eva
Worked for more than 160 Hours: Yes
Contribution to Project:
Ph.D. student

Name: Xia, Yang
Worked for more than 160 Hours: Yes
Contribution to Project:
M.S. student

Name: Fowler, Randy
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Gao, P.
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Gingell, Paul
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Richer, Mark
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Robertson, Mark
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Stepro, Murray
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Toledo, David
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Swink, Michael
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Wang, M.
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Young, Kendal
Worked for more than 160 Hours: Yes
Contribution to Project:

Undergraduate Student

Name: Attagatla, Hari
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Armijo, Jose
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Brinegar, Hilary
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Chairez, Isaias
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Cooper, Brad
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: England, Michael
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Ford, Adriane
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Linnell, Anna
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Logan, Carla
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Lopez, Franchesca
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Lutz, Douglas
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: MacKrain, Katrina
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: McBee, Alan

Worked for more than 160 Hours: Yes
Contribution to Project:

Name: McDonald, Ryan
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Midez, Jaime
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Nance, Amara
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Parham, Jeffrey
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Perez, Oscar
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Salcido, Adam
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Singer, Bethany
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Slaughter, Star
Worked for more than 160 Hours: Yes
Contribution to Project:

Technician, Programmer

Name: Johnson, Jennifer
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Khalil, Nellie
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Meyers, Laura
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Van Zee, Justin

Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Buonopane, Michelle
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Anderson, John
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Nolen, Barbara
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Ramsey, Ken
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Parker, Dara
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Baker, Jennifer
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Campanella, Andrea
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Daues, John
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Huang, Haitao
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Peterson, Terry
Worked for more than 160 Hours: Yes
Contribution to Project:

Other Participant

Name: Whitford, Walter
Worked for more than 160 Hours: No
Contribution to Project:
Collaborated in data review and publications; no direct financial support

Name: Bestelmeyer, Stephanie
Worked for more than 160 Hours: Yes
Contribution to Project:
Executive director of Chihuahuan Desert Nature Park and director of Schoolyard LTER Program (supported by NSF and external funding)

Name: Tartowski, Sandy
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Snyder, Keirith
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Fredrickson, Ed
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Brown, Joel
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Tugel, Arlene
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Arzberger, Peter
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: BassiriRad, Hormoz
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Belnap, Jayne
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Bleiweiss, Max
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Brazier, Richard
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Cushing, Judy
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Ding, Longjiang
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Fountain, Tony
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Jones, Matt
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Kustas, Bill
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Okin, Greg
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Pyke, Dave
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Ritchie, Jerry
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Schmugge, Tom
Worked for more than 160 Hours: Yes
Contribution to Project:

Research Experience for Undergraduates

Name: Apel, Bruce
Worked for more than 160 Hours: Yes
Contribution to Project:

Years of schooling completed: Sophomore
Home Institution: Same as Research Site
Home Institution if Other:
Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree
Fiscal year(s) REU Participant supported: 2001
REU Funding: REU supplement

Name: Bird, Terese
Worked for more than 160 Hours: Yes
Contribution to Project:

Years of schooling completed: Junior

Home Institution: Same as Research Site
Home Institution if Other:
Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree
Fiscal year(s) REU Participant supported: 2000
REU Funding: REU supplement
Name: Lejeune, Michael
Worked for more than 160 Hours: Yes
Contribution to Project:

Years of schooling completed: Freshman
Home Institution: Same as Research Site
Home Institution if Other:
Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree
Fiscal year(s) REU Participant supported: 2001
REU Funding: REU supplement
Name: Hawkins, Lenora
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Hite, Lena
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Leon, Maria
Worked for more than 160 Hours: Yes
Contribution to Project:

Years of schooling completed: Freshman
Home Institution: Same as Research Site
Home Institution if Other:
Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree
Fiscal year(s) REU Participant supported: 2000
REU Funding: REU supplement
Name: Locklear, Adrienne
Worked for more than 160 Hours: Yes
Contribution to Project:

Years of schooling completed: Sophomore
Home Institution: Same as Research Site
Home Institution if Other:
Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree
Fiscal year(s) REU Participant supported: 2001
REU Funding: REU supplement
Name: Matchin, Jaime
Worked for more than 160 Hours: Yes
Contribution to Project:

Years of schooling completed: Sophomore

Home Institution: Same as Research Site
Home Institution if Other:
Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree
Fiscal year(s) REU Participant supported: 2002
REU Funding: REU supplement

Name: Meadmore, Sarah
Worked for more than 160 Hours: Yes
Contribution to Project:

Years of schooling completed: Sophomore
Home Institution: Same as Research Site
Home Institution if Other:
Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree
Fiscal year(s) REU Participant supported: 2003
REU Funding: REU supplement

Name: Sedillo, Ruth
Worked for more than 160 Hours: Yes
Contribution to Project:

Years of schooling completed: Sophomore
Home Institution: Same as Research Site
Home Institution if Other:
Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree
Fiscal year(s) REU Participant supported: 2000
REU Funding: REU supplement

Name: Svensson, Caroline
Worked for more than 160 Hours: Yes
Contribution to Project:

Years of schooling completed: Freshman
Home Institution: Same as Research Site
Home Institution if Other:
Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree
Fiscal year(s) REU Participant supported: 2001
REU Funding: REU supplement

Name: Swink, Michael
Worked for more than 160 Hours: Yes
Contribution to Project:

Years of schooling completed: Junior
Home Institution: Same as Research Site
Home Institution if Other:
Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree
Fiscal year(s) REU Participant supported: 2001
REU Funding: REU supplement

Organizational Partners

Duke University

USDA Agricultural Research Service

Research Foundation of the State University of New York

NOAA Air Resources laboratory

University of New Mexico

University of Leicester

King's College, London

Chihuahuan Desert Nature Park
CDNP is our partner in K-12 educational outreach programs. Specifically, CDNP coordinates the Schoolyard LTER program with schools in the region, operates field trips and classroom visits to carry LTER science to students and teachers, and directs summer workshops for regional science teachers.

USDA Natural Resources Conservation Service

USDI Bureau of Land Management

Other Collaborators or Contacts

World Wildlife Fund, Chihuahuan Desert priority program: sharing information and data regarding patterns of biodiversity and ecological threats to biodivesity in the Chihuahuan region

The Nature Conservancy, Las Cruces (NM) office: Chihuahuan Desert priority and conservation planning program

US-AID (Agency for International Development): in 2001 we hosted a visit by Dr. Franklin Moore, Associate Administrator of AID's Global Environment Centre and previous head of US Delegation to the UN Convention to Combat Desertification.

I-LTER: on behalf of LTER Network, hosted two African visitors (Dr. Susan Ringrose, Botswana, and Dr. Joh Henschel, Namibia) to demonstrate data management and research administration in semi-arid ecosystem science, and to explore potential research collaborations related to the establishment of long-term ecological research programs in southern Africa

UNAM: Collaborations continuing with Dra. Maria del Carmen Mandujano, Instituto de Ecologia, Universidad Nacional Autonoma de Mexico, Mexico City, Mexico, and with other researchers at the Mapimi Biosphere Reserve

INIFAP: collaborations continuing with Dra. Alicia Melgoza, INIFAP, Campo Experimental La Campana, Chihuahua.

Institute of Ecology and Botany, Vacratot, Hungary: Dr. Edit Kovacs Lang.

CARSAME (Center for Applied Remote Sensing in Agriculture, Meteorology, and Environment.

INRAM (Institute for Natural Resource Analysis and Management.

INRA and CNRS, Montpellier, France.

Activities and Findings

Research and Education Activities: (See PDF version submitted by PI at the end of the report)

Findings: (See PDF version submitted by PI at the end of the report)

Training and Development:
Student training, theses, and dissertations:

Apel, B. REU participant, summer 2001, NMSU.

Lejeune, M. REU participant, summer 2001, NMSU.

Locklear, A. REU participant, summer 2000, NMSU.

McGlone, C. MS thesis, Lehmann lovegrass interactions with fire and native plants in a desert grassland, NMSU.

Skarsgaard, A. MS in progress, NMSU.

Svensson, A. REU participant, summer 2001, NMSU.

Swink, M. REU participant, summer 2001, NMSU.

Wang, M.-C. Mapping and monitoring land degradation in southern New Mexico using Landsat data. Ph.D. dissertation, 2000, King's College, London.

2001-2002

Cunningham, L. Ph.D. in progress, 'Sediment yield from different vegetation communities', Leicester.

Duniway, M. Ph.D. in progress, 'Plant-soil feedbacks in arid ecosystems', NMSU.

Endres, A. MA in progress, 'Morphology and Development of Beaded Channels', SUNY Buffalo.

Mueller, E. Ph.D in progress, 'Modelling soil, water, and nutrient fluxes in the Jornada Basin', King's College London.

Perez, Alfonso Serna. Ph.D. in progress, 'CO2 evolution from carbonates', NMSU.

Schmidt, S. Ph.D. in progress, Duke University.

Sheehan, K. MS in progress, NMSU.

Xia, Y. MS in progress, NMSU.

Fowler, Randy. MS in progress, NMSU.

Gao, P. PhD. in progress, King's College, London.

Gingell, Paul. MS in progress, King's College, London.

Richer, Mark. PhD in progress, NMSU.

Robertson, mark. PhD in progress, NMSU.

Stepro, Murray, PhD in progress, NMSU.

Toledo, David, MS in progress, NMSU.

Swink, Michael, MS in progress, NMSU.

Wang, M. PhD in progress, King's College, London.

Young, Kendal, PhD in progress, NMSU.
Postdoctoral training:

Bestelmeyer, Brandon. NMSU, then USDA-ARS. 2000-
Drewa, Paul. USDA-ARS. 1999-2002.
Goslee, Sarah. USDA-ARS, then NMSU. 1998-2002.
Yao, Jin. NMSU. 2001-
Mitchell, Katherine. NMSU. 2001-2003.
Gomez-Landesa, Enrique. USDA-ARS. 2001-
Hochstrasser, T. NMSU. 2001-2003.

Graduate course, Chihuahuan Desert Ecosystems, taught at NMSU by Monger and Huenneke, spring 2000 semester (see Activities).

Teacher training workshops, summer 2000, 2001, and 2002, directed by Chihuahuan Desert Nature Park and including presentations by several LTER investigators.

Internships: Biology undergraduates working with Schoolyard LTER and CDNP to implement access for K-12 students and teachers; two undergrads in 2000.

Outreach Activities:

Two of our primary mechanisms for outreach are our annual research symposium and our semi-annual newsletter. The Friends of the Jornada symposium has attracted a growing audience. The 10th annual symposium (in July 2000), 11th (July 2001),12th (July 2002), and 13th editions (July 2003) featured new formats emphasizing poster presentations and increased chances for discussion Bill Schlesinger passed on the role of editing the Jornada Trails newsletter to Laura Huenneke, who supervised production of fall 2000 and spring 2001 issues. The newsletter reaches a variety of researchers, administrators, and land managers across the United States, and is also available on the Jornada Basin LTER web site.

An additional component of our outreach program has been targeted interactions with resource management practitioners. This has been accomplished in a variety of ways including workshops, seminars, and service on various board of directors. Each year, Joranda staff dveote hundreds of hours to these types of outreach activities. We specifically target individuals and groups that have expressed inteest in information and tehnologies based on current research. An added benefit to this program and the Jornada Basin LTER are the co-location of two resource specialists/scietnists with the NRCS at the Jornada Experimental Range. These specialists (Joel Brown, Arlene Tugel) have been invaluable in providing input and content to our various outreach activities.

Other outreach activities:

H.C. Monger organized and co-led the Desert Project Tour (May 22-25, 2000), which brought 100 scientists from 15 universities, 7 state and federal agencies, 10 consulting firms, and one national lab to NMSU to study desert soils and geomorphology. The Desert Project Tour was highlighted by a television news spot (KRWG-TV, Las Cruces) and by an article in the fall 2000 issue of New Mexico Resources.

Herrick was a SEED mentor at the 2001 ESA meeting

Gillette presented a talk on careers in 'dustology' to children in Baileywick Elementary School, Raleigh, NC (2002)

Schlesinger had the paper 'Desertification Treaty Includes Key Role for Scientists' appear in EOS (American Geophysical Union newsletter) p298 in July 2001.

Huenneke, Havstad, Monger, Herrick, and Peters made presentations and led a field tour on carbon sequestration in arid lands to Tom With, EPA in April 2002.

For the third consecutive year, Jornada LTER and JER scientists spoke at the day-long tour of the Jornada Basin organized as part of the annual Border Book Festival. The 2001 tour was entitled 'Dreaming Back the Desert' and included LTER scientists Curtis Monger and Jeff Herrick speaking to the general audience of about 100 people.

In 2003, we contributed to a week-long rangeland health evaluation training session in Boise, ID and to three training sessions for the NRI in Fort Worth, TX, Rapid City, SD, and Reno, NV. The NRI gathers data on the status and condition of the nation's rangelands and is now using

protocols developed by Jornada LTER reseachers Herrick and Havstad. LTER research results of Gillette and Huenneke are also used in the trainings.

In 2003, we also led several day-long monitoring trainings for ranchers at various locations in New Mexico.

Jeff Herrick led the revision of a co-authored technical reference that describes how to apply a rangeland health evaluation protocol. Over 5000 copies of th first edition ('Version 3.0') were distributed and the process is being applied by land managers throughout the western US. The documents are distributed through training sessions throughout the US, and are available from the BLM and for download as a pdf from various locations on the internet.

Jeff Herrick led the development of six 'Rangeland soil quality information sheets' and co-authored an additional four sheets. The sheets are widely used to introduce land managers, students, and the general public to rangeland soil processes from an ecological (soil quality) perspective. The documents are distributed through training sessions and NRCS and BLM field offices throughout the US, and are available for download as pdfs from various locations on the internet.

K-12 outreach: Schoolyard LTER/CDNP

The Chihuahuan Desert Nature Park is a non-profit organization that serves as partner to the JER and JRN LTER in educational outreach. The CDNP administers the Schoolyard LTER program with NSF supplemental funding, in addition to running other educational programs with private and foundation support. The Jornada Schoolyard LTER 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 human disturbance (trampling).

During the past year the number of participating schools increased to 5 (three elementary, one middle school, one high school) in the Las Cruces and El Paso region. These schools serve relatively low-income, primarily Hispanic populations.

Schoolyard participants also take advantage of the Chihuahuan Desert Nature Park's field trips to the Jornada Experimental Range and the CDNP's 'Desert Science in the Classroom' program. Over 7000 K-12 students and 300 teachers participated in CDNP and Schoolyard LTER activities during the 2000 calendar year.

CDNP, Schoolyard LTER, and LTER staff and volunteers coordinated the First Step teacher training program in summer 2000, and are running another teacher training workshop in summer 2001.

Outreach to land management agencies and range management community:

LTER and JER research was highlighted in week-long Rangeland Monitoring training sessions, each involving ~ 30 practitioners: April 2000 (at Sevilleta LTER) and January 2001 (at Jornada LTER). Similar research findings and principles were used as background for 3 additional week-long training sessions in rangeland health evaluation (held at various western US locations) and for one week-long training in the biology and assessment of microbiotic soil crusts (Jornada, February 2001). A draft version of the manual for monitoring rangeland ecosystems, used in these trainings and by several agencies and NGO's, drew on LTER research findings to inform the design and implementation of quantitative ecosystem indicators.

In 2002, we continued these week-long training sessions in Billings, MT; Chihuahua, Mexico; Audobon Ranch, AZ; Sonora, Mexico; Barstow, CA; and 1 day training sessions in Esteli, Nicaragua.

Kris Havstad serves as board member on the New Mexico State Lands Advisory Board (1999-present).

Kris Havstad serves on the baord of the Quivira Coalition (1997-present).

Public presentations:

D. Peters and L. Huenneke gave invited presentations at the annual meeting of the New Mexico Native Plant Society in Las Cruces, winter 2000.

L. Huenneke spoke on threats to desert biodiversity at a Full Moon presentation, White Sands National Monument, summer 2000.

L. Huenneke organized and presented two of four lectures (on Global Environmental Change and on Human Population Trends) in a series requested by the Academy for Learning in Retirement, a community educational program in Las Cruces NM.

J.E. Herrick was quoted in a Science (Oct 6, 2000) news story on the effects of soil age on the resilience of arid ecosystems (K. Brown, Ghost towns tell tales of ecological boom and bust, Science 290:35-37).

Las Cruces Sun-News story on leadership of LTER returning to NMSU (2001)

Herrick presented two invited seminars at the NRCS Soil Survey Center in Lincoln, NE (2002).

Herrick presented an invited seminar for the New Mexico BLM Resource Advisory Committee on the effects of OHV use on public lands, Las Cruces, NM (2002).

Herrick presented an invited seminar for the US-EPA Border Forum on rangeland assessment in the borderlands and beyond, El Paso, TX (2002).

Huenneke presented an invited seminar followed by an associated field tour to the Las Cruces Chapter of the Sierra Club, Feb. (2002)

Huenneke led a tour of the NMSU biology department and a discussion of affiliated research, including Jornada Basin LTER, for Leadership Las Cruces (a group of community and business leaders, Feb (2002)

Huenneke made a presentation on LTER research priorities to The Nature Conservancy's Arid Lands Network in Las Cruces, NM, May (2002)

Jornada staff provided a tour of the research site to the staff and volunteers of the New Mexico Fram and Livestock Heritage Museum, May (2003).

Jornada staff assisted with the Chihuahuan Desert Nature Park Insect Expo Field Day, May (2003).

Jeff Herrick presented an invited lecture at the bi-annual National Soil Survey Conference in Plymouth, MA, July (2003).

Kris Havstad cooridnated with Jon Boren, New Mexico Extension Animal Resources Specialist, a tour of the Jornada for ca. 2500 4-h students, National 4-H conference, July (2003).

Journal Publications

Buck, B.J. and H.C. Monger, "Stable isotopes and soil-geomorphology as indicators of Holocene climate change, northern Chihuahuan Desert.", Journal of Arid Environments, p. 357-373, vol. 43, (1999). Published

Cross, A.F. and W.H. Schlesinger, "Biological and geochemical controls on phosphorus fractions in semiarid soils.", Biogeochemistry, p. 155, vol. 52, (2001). Published

Abrahams, A.D., G. Li, C. Krishnan, and J.F. Atkinson, "A sediment transport equation for interrill overland flow on rough surfaces", Earth Surface Processes and Landforms, p. 1443-59, vol. 26, (2001). Published

Fredrickson, E.L., D.M. Anderson, K.M. Havstad, W.L. Shupe, and M.D. Remmenga, "Pen confinement of yearling ewes with cows or heifers for 14 days to produce bonded sheep", Small Ruminant Research, p. 291, vol. 40, (2001). Published

Fredrickson, E.L., R.E. Estell, K.M. Havstad, W.L. Shupe, and L.W. Murray, "The effect of feeding ewe lambs a 15 % tarbush (Flourensia cernua) pellet pre- and post-weaning on the subsequent diet selection of tarbush", Journal of Arid Environments, p. 123, vol. 44, (2000). Published

Gillette, D. and W. Chen, "Particle production and aeolian transport from a 'supply-limited' source area in the Chihuahuan Desert, United States", Journal of Geophysical Research, p. 5267-78, vol. 106(D6), (2001). Published

Granados-Olivas, A. and H.C. Monger, "Remote sensing technology for development planning along the US-Mexico border: hydrogeology and geomorphology", New Mexico Journal of Science, p. 123, vol. 39, (1999). Published

Hartley, A.E. and W.H. Schlesinger, "Environmental controls on nitric oxide emissions from Northern Chihuahuan Desert soils", Biogeochemistry, p. 279-300, vol. 50, (2000). Published

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Web/Internet Site

URL(s):

jornada.nmsu.edu

Description:

Home page for Jornada Basin LTER program; provides links for personnel, for site bibliography (searchable now in several ways), for available data sets, for documentation on LTER and LTER-related projects.

The Jornada LTER bibliography is now searchable over the Internet using ISI Research (ProCite) Reference Web Poster software. The bibliography site can be accessed at http://128.123.5.143/ris or from the Bibliography page accessible from the Jornada LTER home page. The Research Notification table is now queryable over the intranet and accessible to JRN and JER site managers, to aid in research site selection and approval.

Other Specific Products

Product Type: Teaching aids

Product Description:

Undergraduate interns for the Schoolyard LTER program wrote and enhanced classroom activity guides to provide followup to field visits to the Jornada site.

Sharing Information:

The classroom activity guides are distributed through the Chihuahuan Desert Nature Park's educational activities, including classroom visits, teacher training workshops, and field visits by classes to the Jornada site.

Product Type: Teaching aids

Product Description:

Fact sheets on various LTER and JER studies were produced for assembly into tour books that can be produced and customized for particular

Sharing Information:

These materials are reproduced and distributed to visiting researchers, representatives of land management or research agencies, and public groups; they have proven useful in translating research projects into terms meaningful to the general public and to policy-makers and managers in the region.

Product Type: Teaching aids

Product Description:

A manual introducing quantitative monitoring methods for grassland and shrubland ecosystems has been developed and used extensively in training land managers and private individuals.

Sharing Information:

The draft manual is distributed and used in training sessions, is being used by representatives of a number of agencies and NGO's, and is in review for publication in book form.

Contributions

Contributions within Discipline:

Significance to ecology:

The resource redistribution desertification model articulated by Jornada researchers has been a primary conceptual model for ecosystem work in arid and semiarid systems. The concept that shrub dominance in former grassland establishes and exacerbates patchiness in soil resources has stimulated much work. In particular, the focus on the importance of physical redistribution processes and on the interactions between plant properties and abiotic influences has been a productive stimulus for ecosystem ecologists.

The Jornada basin has long been a key location for empirical description of one of the primary forms of desertification (a global problem). The infrastructure provided by the LTER program has facilitated the Jornada's status as a premier location for experimental and process-level studies.

Key findings based on our long-term work and studies illustrate the pace of response of desert organisms to perturbations and environmental drivers. In particular, we have demonstrated:

- the long lag time for vegetation and soil responses to some disturbances (e.g., the removal of key dominant plant species);
- the response of the system to some changes (e.g., human interference with surface flows of water) only after many decades;
- the inertia provided by shrubs and their enforcement of soil heterogeneity.

The Jornada Basin has also been a key location for understanding the development and function of aridland soils (the Desert Soil Project) and the interaction of soils with vegetation (both as driver and as effect).

A final subdiscipline within ecology in which Jornada research has been important is rangeland ecology. The Jornada Experimental Range, NMSU's College of Agriculture Chihuahuan Desert Rangeland Research Center, and most recently the Jornada Basin LTER are known as major research centers for range science. Jornada scientists have contributed key investigations of the interactions between livestock and other semiarid ecosystem components, from phytochemistry to soils.

Contributions to Other Disciplines:

Contributions to other scientific disciplines

As noted above, the Jornada has been an important program supporting the efforts of soil scientists to understand the development and properties (both intrinsic and dynamic) of arid-land soils. LTER research has been particularly important in allowing geomorphologists and soil scientists to explore the feedbacks between soil properties and vegetative cover over different temporal scales.

Jornada-based research is contributing to the development of earth system science and the understanding of several phenomena linked to global environmental change. Specific examples include the interactions between desertification and resulting generation and export of dust, and changes in albedo. Model development here should refine our ability to model biosphere response to climatic change. Finally, the new lines of Jornada work aimed at understanding carbon budgets and soil carbon and carbonate dynamics are addressing major gaps in our understanding of global carbon balance.

The Jornada is actively supporting the development of remote sensing technology and analysis. Remote sensing in arid regions has been constrained by technical difficulties (such as the predominant influence of the soil surface signal), but the vast expanses of relatively inaccessible arid lands with significant large-scale variation will demand remote sensing for adequate observation. Ground truth data and extensive process-level studies are available for cross-referencing with remotely sensed imagery from aerial and satellite platforms at the Jornada (e.g., the JORNEX and PROVE campaigns). There are few such well-studied locations in semi-arid and arid ecosystems, and thus the Jornada promises to become even more important in extending our capabilities.

Contributions to Human Resource Development:

The Jornada Basin LTER and associated projects support several postdoctoral researchers and attract visiting postdoctoral scientists supported

by other institutions or agencies (e.g., CONACyT). The program supports (directly or indirectly) 6 - 12 or more graduate students at a time, doing thesis or dissertation research related to LTER themes and objectives. The primary academic institutions in which these students earn or are working toward degrees include NMSU, Duke University, SUNY-Albany, and King's College - London.

The Jornada Basin LTER program routinely supports 1 - 3 REU students each summer (and into the academic year where the student's location and schedule permit). NMSU is classified as a minority, Hispanic-serving institution, and we have routinely included minority and female students in our REU program.

Contributions to Resources for Research and Education:

Field station and field researchers' capabilities:

A supplement to the LTER has provided fiber optic and T-1 connectivity to the Jornada Experimental Range headquarters. Recent renovation of a historic building at that site (the Turney house) has provided a small meeting room and some office space for JER personnel; thus the area is developing as the nucleus of a field facility.

The Jornada program's 'pool' of cell phones are routinely used by LTER and non-LTER researchers and visitors to provide a safety communication mechanism in the remote and difficult terrain.

The Jornada GIS and the spatial database maintained by the JRN site office are being used increasingly for selection and coordination of suitable field sites for prospective projects.

Information resources:

The LTER site bibliography (and search/query capabilities developed this year) have been extensively used by students and instructors as well as researchers.

Contributions Beyond Science and Engineering:

Contributions to the public welfare and societal concerns

LTER research findings have been used in the development of assessment and monitoring methods appropriate for semi-arid ecosystems. Much of the American west comprises such systems, and there is substantial and contentious debate over the appropriateness of particular land uses and their impacts on ecosystem (and economic) sustainability. These applications thus provide tools needed by regulatory and land management agencies as well as individuals.

Human population and land use patterns are changing rapidly around the world (not just in the arid southwestern US). Jornada research helps to provide a basic understanding of the limits to management of livestock in semiarid systems. Moreover, Jornada research on biodiversity, rangeland water and air quality, and other aspects of human-environment interactions is being used in regional efforts to understand and manage other human activities in semiarid ecosystems (beyond livestock production).

Impacts on scientific literacy in the region:

The Schoolyard LTER program and affiliated educational programs are explicitly attempting to improve the rigor and appeal of scientific education at the K-12 level. We operate in a region of the US with largely poor, largely minority populations (schools in the Las Cruces region routinely have student bodies that are 50 - 80 % Hispanic, with 60 - 90 % of the students qualifying for free/reduced lunch program). Thus the program addresses scientific literacy at the earliest stages for a diverse, under-served population.

Special Requirements

Special reporting requirements: None

Change in Objectives or Scope: None

Unobligated funds: less than 20 percent of current funds

Animal, Human Subjects, Biohazards: None

Categories for which nothing is reported:

Overview: The Jornada Basin LTER program has maintained a long-term focus on desertification, encompassing both mechanics and consequences. Through the first three funding cycles, the chief conceptual model highlighted spatial heterogeneity of both biotic and abiotic elements of semi-arid ecosystems. Our specific focus was on the redistribution of soil resources at the plant-interplant scale – the Jornada desertification model. As outlined in our most recent renewal proposal, we are now aiming at a better understanding of the consequences (an interactions with other agents of global change) of desertification, and of integrating our approaches to better understand redistribution processes and consequences at multiple scales. In particular, we are interested in the degree to which redistribution forms the basis of linkages among landscape units and determines whether the Jornada Basin as a whole behaves as a source or sink for importance resources.

The major activities of the period since submission of our renewal proposal (January 2000) are reported here under the following categories:

1. Studies of transport processes, fluxes, and biogeochemistry of soil resources.
2. Work aimed at developing a landscape perspective or at integrating multiple spatial and temporal scales.
3. Studies of disturbance and recovery processes.
4. Investigations capitalizing on the extended history of research at the Jornada (dating back to early 20th century studies).
5. Cross-site studies, both within the LTER Network and with non-LTER sites.
6. Information management and infrastructure.
7. Scientific presentations at meetings, workshops, etc.
8. Other activities: site synthesis volume, graduate course.
9. Associated grant and contract funding.

1. Studies of transport processes, fluxes, and biogeochemistry of soil resources

Much of our empirical and analytical effort has focused on the agents of redistribution (particularly wind and water), and the biogeochemical results of the action of those agents. Other work is aimed at understanding the distribution of, availability of, and interactions among important resources for plant growth (particularly soil water).

a. **Hydrobiogeochemistry:** The field season of 2000 was largely spent conducting some rainfall simulation experiments in the mesquite habitats, focusing on bare and vegetated plots, to determine sediment and nutrient transfers in runoff. These experiments, conducted following the protocols of Schlesinger et al. (1999), produced data on runoff volume, sediment yield, infiltration capacity, and nutrient transport. A draft manuscript reporting these data is in hand, with anticipated submission later this summer. Prototype runoff/sediment/nutrient samplers were installed in summer 2000 for evaluation of performance under field conditions. In 2000, there was also collection of vegetation and soil samples in and adjacent to areas of sediment deposition by discontinuous channels in areas of creosotebush. In spring 2001, the tested runoff/sediment/nutrient samplers were installed at 91

inter-rill sites along vegetation ecotones. Five stock ponds suitable for installation of pressure transducers to measure landscape-scale runoff amounts and timing from different vegetation communities were identified, and instrumentation of these was to be completed in summer 2001. Bedload sediment samplers were added to existing instrumented watershed in creosotebush bajada.

In the summer of 2001, we installed stilling wells, pressure transducers, and data loggers in the five selected stock ponds. We also installed scour chains in rills in the existing instrumented watersheds in the creosotebush bajada, and colleced data from the samplers installed in the spring. The summer of 2002 was the first field season for two new graduate students. Fieldwork consisted of the survey of 20 stock ponds (including the 5 instrumented ones) and collection of soil samples and vegetation measures from within the catchments of the 5 instrumented stock ponds. The interrill runoff and sediment samplers were modified in response to data collected in summer (2001). We also installed rill samplers in 12 rill sites. We also continue to analyze runoff samples from the North and South Flumes and from the new array of runoff samplers placed throughout the Basin. While there is some doubt about the integrity of the latter, the former is beginning to amass a long-term data set documenting runoff nutrient losses from hillslope positions. [Schlesinger, Parsons, Wainwright]

b. **Jornada Basin biogeochemical budgets:** Sebastian Schmidt, a Ph.D. student at Duke, is compiling present-day and historical budgets for the pools of carbon and nitrogen in the soil and vegetation of the Jornada Basin, and flux budgets for CO_2, CH_4, and N_2O. For methane, efflux terms include production by ruminant animals and uptake by soils, are being measured by field studies during summer 2001. These budgets, in combination with historical maps of vegetation in the Basin, will allow us to evaluate the source/sink relation of the Jornada Basin with respect to the atmosphere for specific times since the mid-1800s up to the present. [Schlesinger, Schmidt]

c. **Studies of fluxes of inorganic carbon in desert soils:** Five graduate student projects have been established to advance our understanding of the role pedogenic $CaCO_3$ plays in the C cycle. The questions being asked are the following: i – Do termites biomineralize carbonate crystals as a cementing agent for gallery construction?; ii – Is CO_2 released from exhumed petrocalcic horizons during rain?; iii – What is the ratio of below-ground carbon to above-ground carbon in black grama grasslands and mesquite shrublands?; iv – How does temperature and soil texture affect soil carbonation formation?; and v – Can x-ray diffraction analysis distinguish limestone-carbonate from pedogenic-carbonate in desert soils? Funding for these projects is provided by the LTER (1 student) and a USDA-NRI grant (1 student). The other two students are supported by NMSU teaching assistantships. The next phase of our LTER studies will focus on combining the spatial scale with the temporal scale. This will involve investigations of long-term resource fluxes based on maps of Holocene depositional and erosional units (both eolian and fluvial). It will also involve

investigations of short-term resource fluxes based on small irrigation studies with Schlesinger to test hypotheses dealing with water movement in the soil profile, solute movement, mineral formation and soil gas dynamics.

In 2001-2003, Haiyang Xing, a M.S. student supported by LTER, completed a study in which he measured root carbon, soil organic carbon, soil carbonate carbon, and above ground carbon in three black grama grassland sites and three mesquite duneland sites. Xiaoyun Liu, a Ph.D. student supported by a NMSU teaching assistantship, has completed a study at the Jornada in which she used carbon isotopes, x-ray and optical mineralogy, and electron microscopy to test the hypothesis that termites generate $CaCO_3$ crystals as a cementing agent for gallery construction. Becky Kraimer, a Ph.D. student supported by an EPA grant, is testing the hypothesis that x-ray crystallography can be used to distinguish between (1) limestone particles in soil and (2) pedogenic carbonate formed in soil. Alfonso Serna-Perez, a Ph.D. student supported by CONACYT, is using soda lime and NaOH traps to test the hypothesis that eroded calcic soils will release more CO_2 to the atmosphere than uneroded soils. Marco Inzunza-Ibarra, a Ph.D. student supported by a USDA-NRICGP grant, is using a series of lab experiments to measure the amount of CO_2 consumed during the formation of $CaCO_3$ under various temperature and drying scenarios. [Monger]

d. **Development of a dust emissions model for the Jornada Basin:** A primary objective of the project is to develop a model for the aerodynamic effects of the vegetation and soil properties at each of the 15 long-term NPP sites. The dominant dust-producing NPP sites are the three mesquite sites. During April 2000, Gillette obtained additional funding from the US Army Center for Health Promotion and Preventative Medicine, at the Aberdeen Proving Ground (MD) to conduct an intensive study of erosion at the three mesquite sites. During that time D. Gillette and A. Pitchford of the US EPA National Exposure Research Laboratory at Las Vegas made measurements of PM10 (particle mass concentration for particle size smaller than 10 micrometers) and horizontal sand fluxes from surface to 1 m height. Observations were made for 4 x 4 or 4 x 5 grids at each of the mesquite sites for sand storms on April 15 and April 18-19, 2000. Data from the intensive experiment have been analyzed for the sand fluxes. A manuscript is in the final stages of preparation. To integrate wind observations, vegetation mapping, and sand flux monitoring, a mathematical model was constructed of the mean airborne sand mass flux. The model was an expectation integral that used information about the increase of sand flux with length of the street, a function for the horizontal mass flux based on friction velocity and threshold friction velocity, wind speed probability versus wind directions, probability of street lengths versus direction and probability of friction velocity. The model calculations of mean sand flux movement showed fairly good agreement with the observed mean sand fluxes at three mesquite sites.

In 2001-2003, we focused on the strongest sources of dust in the Jornada LTER We tested two hypotheses: (1) that land dominated by mesquite (*Prosopis*

glandulosa) is the most important area for active sand movement at the Jornada Experimental Range, and most possibly in the northern part of the Chihuahuan desert, and (2) that the most active sand movement in the mesquite-dominated ecosystems takes place on elongated bare soil patches (streets) between the mesquite plants oriented in the direction of the strongest winds. Evidence for the confirmation of both these hypotheses was found by sampling wind erosion sand movement in 15 locations typical of Jornada ecosystems. These 15 Net Primary Productivity (NPP) locations represented five distinct ecosystems of which the mesquite possessed the most severe wind erosion.

To investigate physical mechanisms involved in the strong wind erosion of mequite streets@, we integrated wind observations, vegetation mapping, and sand flux monitoring to model the spatial and temporal mean airborne sand mass flux. The relationships of (1) increase of wind erosion with length of unprotected soil and (2) horizontal-mass-flux with friction velocity and threshold friction velocity were developed from data from a 100 m diameter unvegetated semicircle roughly in the center of the Jornada Experimental Range. The model predictions of mean sand flux movement showed good correlation with the observed mean sand fluxes at three sites dominated by mesquite vegetation. By completing the wind erosion/dust emission model for the mesquite ecosystems, we will have a component for a wind erosion/dust emission model for the whole Jornada LTER.

Current unfinished work shows that streets (unvegetated elongated areas) within the mesquite areas often parallel the wind direction of the strongest winds. Research is now underway to quantify the following: (a) origin of the Astreets@ (b) detailed aerodynamic measurements of wind stress and sand movement within the Astreets@ (c) patterns of deposition of sediment in the mesquite ecosystem. Using this work and earlier wind erosion threshold friction velocity work, we intend to use existing wind and airborne-sediment monitoring to form a prototype model of wind erosion and dust emissions for the Jornada LTER area. We invited the LISA (Laboratoire Interuniversitaire des Systemes Atmospheriques) dust emissions group to apply their model to the Jornada LTER. We will work with them in adapting roughness, threshold, and wind parameterizations that are products of our smaller scale Jornada research for the LISA model. The LISA dust model has been successfully tested for large scale dust emissions from the Sahara desert. [Gillette]

e. **Measurement of atmospheric deposition at each of the 15 NPP sites:** Atmospheric deposition collection devices of the same design as used by the US Geological Survey in its deposition sampling program in the Mojave were installed at the 15 NPP sites in March 2001. After a rusting problem was identified by LTER personnel, the collectors were retro-fitted with stainless steel connectors to correct the problem. The intent is to enable quantitative measurement of dust deposition at each site, and eventual analysis of the chemical composition of that dust, to facilitate the estimation of basin-level biogeochemical budgets.

In 2001-2003, we addressed initial problems with bird fecal material by modifying the original design to prevent bird perching. Collections of atmospheric (wet and dry) deposition will be evaluated. Once the design has been shown to prevent bird contamination, continuous monitoring is planned until at least September 30, 2002. These measurements will provide (coupled with emission data from the above experimentation) a measure of the net loss/deposition of soil nutrients by wind in the Jornada LTER area. [Gillette, Schlesinger]

f. **Dust generation from unpaved roads:** A side project was initiated by a graduate student in 2000-2002 who is examining the effects of dust generated from dirt roads on lichens and other soil crust-forming organisms. Approaches include both field assessment of the magnitude and distance of dust transport from roads and greenhouse/laboratory study of the effect of experimental dust applications on viability and photosynthetic capabilities of crust organisms.

   In 2001-2003, this student demonstrated that dust deposition on the soil surface near dirt roads is highly variable. The student also developed protocols to determine the amount of dust deposition that crusts can tolerate before mortality occurs. [Herrick, Huenneke, Skarsgaard]

g. **Soil water availability:** We recruited a graduate student to the project, one of whose responsibilities will be to quantify the relative contribution of different forms of caliche to soil water availability at the 15 NPP plots.

   In 2001-2003, this student spent most of the year developing and refining a protocol for measuring the moisture retention characteristics of calcic horizons. The water stored in these horizons is believed to play an important role in grass-shrub dynamics. [Herrick]

h. **Plant water relations, water vapor flux, and heat flux:** Understanding the physiology of dominant shrub species is crucial to understanding fluxes within and from shrubland sites. Studies of water relations in creosotebush are being carried out with LTER support. One project follows the dynamics of creosotebush recovery from drought. Shrub attributes (including photosynthetic parameters such as maximal carboxylation capacity, quantum yield from chlorophyll fluorimetry, and stomatal control parameters; soil water content; tissue water status; and leaf area) have been followed for four years to understand how individual shrubs survive drought and capitalize on short re-wetting events. Many patterns of acclimation to drought and of recovery dynamics were observed. An analysis of 1300 gas-exchange data sets was complete, using the best available models of photosynthesis. Another project investigates how heat flow in creosotebush stems protects the cambium cells from lethal temperatures. Thermocouples monitored temperatures at stem centers and cambial layers, and the observed patterns were used to develop heat-flow models. Initial estimates for (protective) heat flows were developed, based on aggregating parts of the stem

into zones of heat-influx and heat-efflux. The simple resistance model indicated that heat flow by conduction in wood is much too weak to afford protection. Next heat flux by sapflow (supporting leaf transpiration) was quantified. The observed rate of water flow, with a 15°C gain in temperature, transports almost exactly the projected heat influx. Finally, physiological control of water use is being assessed, Measurements of leaf gas exchange on a number of plant species on the Jornada by Gutschick and his research group have revealed a close agreement of measured stomatal conductance with that predicted from the Ball-Berry model (Ball et al. 1987) that is widely used in climate modeling and hydrology. However, this model only applies to control by the immediate environment of the leaf (PAR flux density, temperature, windspeed, and CO_2). An additional layer of stomatal control by toot-sourced water stress signals (ABA, abscisic acid) is clear in both herbaceous plants (Tardieu et al. 1998) and woody plants (Niinemets et al. 1999). On sabbatical visits to the laboratory of F. Tardieu in Montpellier, l'Herault, France (supported in part by a supplement to the LTER), Gutschick developed a model synthesizing the Ball-Berry and ABA models. In 2001, final data analyses were made and the manuscript finalized for submission. Long-standing conceptual problems in statistical analyses of the Ball-Berry model were resolved; such problems had limited some application of the model outside of climate and hydrology studies. The joint Ball-Berry / ABA model is being developed for use with soil water status rather than difficult-to-assay ABA as a driving variable. Its application on the Jornada is anticipated. [Gutschick]

In 2001-2003, we examined four years of data on the physiology and leaf development of 20 individual creosote plants to determine commonalities in gas exchange and water status behavior as well as differences in recovery of leaf area development. We found that branch respiration is maintained throughout drought, and that respiration becomes very high during strong recovery of leaf area development. We also used image analysis to quantify leaf area dynamics. 120 images (out of a total of 800) were digitized, digitally corrected for lighting and film response, cropped and rectified, and analyzed pixel-by-pixel for leaf presence. The mean fraction leaf in a moving window was used to estimate local leaf area index (LAI). The local LAI was multiplied by physical area to yield total leaf area on each shrub at 20 dates. Rapid leaf development coincided with very high branch respiration. We are proceeding to relate leaf development, photosynthetic rate, and dark respiration to recent histories of plant water status.

i. **Carbon sequestration studies:** The EPA has funded a project to examine and quantify spatial patterns in carbon dynamics to additional plant communities at the Jornada, the Sevilleta LTER site, and 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 affect carbon sequestration in different parts of the landscape.

In 2001-2003, we began constructing inventory maps of organic and inorganic carbon in the Desert Project area that includes some of the Jornada Experimental

Range and most of the CDRRC. Based on Desert Project soil data, organic carbon ranges from 1.5 to 8.4 kg/m^2 and inorganic carbon ranges from 0.3 to 230 kg C/m^2. Using the CENTURY model, we are quantifying changes in carbon storage through time, both with and without informed management practices. We posit that the Chihuahuan Desert ecosystem has served as a carbon sink during the last century due to the conversion of grasslands to shrub savanna. Our working hypothesis is that shrub encroachment in desert grasslands increases belowground C sequestration: a) the large woody root systems of shrubs increases belowground plant C, and b) the slow turnover rates of decomposing woody root tissues significantly augment soil organic carbon pools. Since woody plant encroachment into grasslands is occurring worldwide, ecosystem-level changes in carbon pool sizes have important ramifications for global carbon cycling estimates. We are also conducting research in grasslands and shrublands at the SEV-LTER as well as in pinyon-juniper ecosystems in northern NM. Our research approach combines direct field measurement of carbon pools, improved analytical approaches to soil C assessment, development of new models for soil inorganic C pedogenesis, and landscape-scale simulation modeling. Our goal is to extrapolate field-based estimates to regional-scale predictions of carbon dynamics.

We are currently adapting the CENTURY model to simulate biogeochemical processes of arid grasslands and shrublands. We met with a group of CENTURY modelers (Parton) and the CASCGMS group (Paustian et al.) at CSU in June (2002) to discuss potential collaborations relative to modifying CENTURY for aridlands. We also met with SGS LTER scientists (Burke, Kelly) to develop collaborations relative to modifying CENTURY for inorganic carbon and to simulate carbon at depths >> 20cm. We are currently developing a new model to predict rates of formation of calcium carbonate (caliche) in arid soils. The calcium carbonate model will serve as a sub-module within CENTURY, and will incorporate feedbacks between soil carbonates and sokl water availability. After CENTURY has been modified for characteristics of aridlands, we will link CENTURY with ECOTONE to allow dynamic feedbacks between soil carbonates, soil water, and recruitment, growth and mortality of plants. [Monger, Peters, Herrick, Mitchell]

j. **ECOTONE extension:** The US Army has funded work to extend the ECOTONE simulation model of vegetation and soil water dynamics to additional plant communities at the Jornada and on Fort Bliss, TX. ECOTONE was originally parameterized for blue grama, black grama, and creosotebush communities at the Sevilleta. The model is now being parameterized for other important shrubland, grassland, and mixed-dominance associations.

In 2001-2003, we conducted an extensive literature review to obtain model parameters for the major plant species in Chihuahuan Deserts. This literature review is contained in a bibliography submitted to CERRL for publication. We also developed a conceptual model of the interactions between vegetation, climate, and small mammal disturbance at grassland-shrubland ecotones. We are

incorporating disturbances into ECOTONE in a much more comprehensive and mechanistic way than used previously in the model. [Peters, Hochstrasser]

2. **Developing a landscape perspective and integrating multiple spatial and temporal scales**

   a. **Geomorphic mapping:** We continued geomorphic mapping to delineate landforms in the Basin, with the ultimate aim of integrating these maps with biogeochemical studies in determining the Basin's status as a source or sink of resources. Our geomorphic mapping covers an area of approximately 2500 km^2, extending from the southern boundary of CDCRRC to the Point of Rocks north of JER, and from the San Andreas Mountains to the Rio Grande. To date, this mapping endeavor consists of three maps produced on Landsat images: a physiographic map, a parent material map, and a landform map. The physiographic and parent-material maps are essentially finished and have been digitized. The landform map is scheduled for completion in September 2001.

   In 2001-2003, we completed maps of phyisographic units, parent materials, and landforms at the Jornada Basin LTER site. The maps, which cover an area of 2500 km^2, will be used to analyze links between ecosystems and landscapes. The physiographic map is the most general with four categories: mountains, piedmont slopes (bajadas), basin floors, and the Rio Grande valley. The parent material map contains 33 categories, such as granite bedrock, limestone alluvium, and gypsiferous clay deposits. The landform map contains 23 categories, such as alluvial fans, longitudinal dunes, and playas. [Monger, Nolen]

   b. **Historical soil maps:** In order to better understand soil resources, the program produced digital map layers from the 'rescue' of 1918 and 1962 soil maps of the Jornada Experimental Range. We can now compare (digitally) the 1918, 1962, Dona Ana Soil Survey, and Desert Project soil maps. These digital maps will soon be available for LTER researchers and will be included in the Soils chapter of the Synthesis Volume. [Monger, Nolen]

   Historical vegetation maps: Other digital map layers added to the Jornada GIS include JER vegetation from 1915, a 1942 map of vegetation on the NMSU College Ranch (now the Chihuahuan Desert Rangeland Research Center, CDRRC), and R. Gibbens' recent re-mapping of vegetation on both the JER and the CDRRC. [Nolen]

   c. **Spatial and temporal patterns of NPP:** We continued the seasonal monitoring of plant species composition, aboveground biomass, and aboveground net primary production at the network of 15 permanent sites (3 in each of the 5 different vegetation types). We completed and published an analysis of the methodology and power of this design for testing statistically for differences among vegetation types of among seasons. We also submitted a manuscript describing the general patterns of aboveground productivity in the 15 sites over the first 10 years of data

collection, focusing on the significant differences between shrub-dominated and grass-dominated ecosystem types.

In 2001-2003, we continued sampling the NPP plots. We also published a manuscript showing patterns in NPP for the different plant communities. [Huenneke]

d. **Remote sensing of ANPP and vegetation characteristics:** Satellite data from Landsat were purchased for use in studying effectiveness of spectral vegetation indices for assessing net primary productivity. JORNEX campaigns were successfully conducted over CDDRC and JER study areas in September 2000 and May 2001.

In 2001-2003, we conducted four JORNEX campaigns. In Sept., the project was limited in scope due to the grounding of airplanes in the aftermath of 9/11. Satellite and ground data were acquired. The Spring JORNEX went according to schedule on May 13-16, although data acquisition was limited by the White Sands Missile Range, again in response to 9/11. Certain flight lines could not be flown, but significantly more data were acquired than in the previous fall. The major accomplishment was the complementary analysis of ground data in historical shrub removal plots in both tarbush and creosote sites. We duplicated ground measurements made in 1939, re-photographed treatments at the exact spots used in 1939, and analyzed the aerial photos taken in the 1930's and 1940's. Progress continues to be made on analysis of Landsat TM data over the entire Basin and also at the NPP sites. [Rango]

e. Synthesizing long-term data sets: A nationwide search was conducted to fill a postdoctoral position with the LTER. This position will synthesize and integrate various LTER and ARS long-term data sets with a focus on understanding and predicting long-term changes in the vegetation as related to soil properties, land use history, animal distribution and patterns of use, water and soil redistribution, The vegetation data sets of primary interest are the long-term ARS chart quadrats located throughout the Jornada basin, the vegetation maps recreated by Bob Gibbens, and the LTER NPP data collected by Laura Huenneke. Dr. Jin Yao was hired in early June to work on this project. Jin received her PhD from the University of Kansas in December 2000, and has an extensive background in vegetation analyses conducted across spatial and temporal scales.

In 2001-2003, we examined spatial and temporal variation in vegetation using the long-term chart quadrat data. A total of 106 1 m^2 permanent quadrats set up during 1915-33 across a range of vegetation types are being analyzed. At the time of set up, 58 quadrats were in black grama grasslands, 22 in tobosa grasslands, 12 in burrograss, 6 in threeawn grasslands, 6 in blue grama grasslands, and 1 in a gypsum-dropseed grassland. Quadrats have been measured periodically to quantify changes in cover through time. We also remeasured the quadrats in fall 2001. We are comparing vegetation data with other long-term data collected at

multiple spatial scales to identify the landscape, climatic, and anthropogenic factors that influence perennial grass abundance, growth, and persistence. We are including additional data layers, such as grazing management and stocking rate, as they become available. These results have been presented at two national meetings and will be submitted to journals for publication in the near future. [Yao, Peters, Herrick, Huenneke, Havstad]

f. **Landscape modeling:** We are continuing to develop, redesign, and expand the capabilities of the ECOTONE model. Originally a vegetation dynamics or succession model, ECOTONE is being expanded to include soil water, nutrients, soil erosion, and animal interactions with plant, patch, and landscape features.

In 2001-2003, we have been thoroughly testing the capability of ECOTONE to represent grasslands and shrublands in arid and semiarid regions. We are improving the efficiency of the code to allow large landscape units (>1000 m^2) to be simulated. Given the small plot size (< 2 m^2), increasing code and input/output efficiency has been a major focus. We also modified ECOTONE to run under the Windows operating system instead of UNIX. This change will increase the accessibility of the model to a larger group of users, and will allow us to take advantage of the broad array of user-friendly applications available on PCs. We are investigating alternative soil water models that will allow us to redistribute water horizontally as well as vertically with depth. We started development on a meta-modeling approach that will allow us to simulate large areas within the Jornada Basin. We will continue this meta-modeling approach over the next year using output from the fine-scale, process-based ECOTONE model. This modeling is a collaborative effort among a number of scientists at the JRN and SEV LTER as well as postdocs working under separate funding. [Peters]

g. **Extrapolation of information across spatial and temporal scales:** This synthesis effort involves a number of JRN scientists, and relates directly to our new focus on landscape linkages. We convened three workshops at the LTER All Scientists meeting in August 2000 that dealt with the problem of extrapolating information across spatial scales. These workshops were followed by a synthesis workshop held at the SEV field station in March 2001. At that time, three working groups were formed: (1) carbon inventory and dynamics, including water, (2) invasive plants and changes in species and functional group geographic distributions, and (3) animal interactions with their environment. Two major conclusions were drawn from these groups. First, although extrapolation of information across scales has been an important topic in ecology, we still lack an organizing framework that provides an objective way to decide which scaling approach to use, and states the strengths, limitations, assumptions, and consequences of each approach. Second, scaling problems are very similar among different disciplines (animals, plants, soils), expertise (theoreticians, modelers, experimentalists), and perspectives (top-down, bottom-up).

In 2001-2003, this group continued to address these scaling issues with the overall goal of developing a synthetic problem-solving approach for extrapolating information from fine to coarse scales. To meet this goal, we organized a symposia at the International Association for Landscape Ecology meetings held in Lincoln, NE in April. We are now working on four manuscripts to be submitted for publication in the next 6 months. The JRN has been a major presence in these groups from the beginning, and continues to lead this effort. We also submitted a manuscript describing our approach to Oikos (March 2003) [lead: Peters]

3. Long-term studies of disturbance and recovery processes

a. **Soil surface disturbance experiment:** In 1997, a study was initiated under non-LTER funding to apply several types of surface disturbance to desert soils and monitor recovery of soil properties. Surface disturbance plots established in tarbush and creosote plant communities were re-measured and half of each plot was re-disturbed in 2001. While the data have not yet been analyzed, preliminary observations indicate that complete recovery of most soil indicators had occurred at the creosote site, which is dominated by weak cyanobacterial crusts, but not at the tarbush site, which is dominated by soil lichens.

   In 2001-2003, we continued this study by re-measuring plots and began measuring penetrometer resistance. Preliminary results from a related study in the Tularosa Basin east of the Jornada and at Lake Mead National Recreation Area show that relatively limited disturbances (two passes of a small jeep with low-pressure tires) can cause significant compaction even on dry soils. [Herrick]

b. **Plant diversity experiment:** This large-scale experiment to understand the impact of reduced species and growth form diversity was maintained and re-sampled. Analyses of plant community composition and recovery through the first 5 years have now been completed and a manuscript is in preparation; preliminary results were presented at several meetings, and the study was incorporated into the GCTE Network of Species Removal Experiments.

   In 2001-2003, we continued collecting data from these plots. [Huenneke]

c. **Stressor experiment:** We examined the effects of fire and acute overgrazing on vegetation community responses in the presence of an invasive shrub, *Prosopis glandulosa*, in northern Chihuhuan desert grasslands. Winter, summer, or no acute overgrazing treatments, in the presence and absence of *Prosopis glandulosa*, were applied annually to six 0.5 ha plots within each of three blocks (the stressor experiment) from 1995-2001. Cattle utilization was 65-80% of current year's growth in a single <36 hour period annually. One of two 4m x 5m subplots was burned within each of these 18 plots in August 1994. Cover and frequency of non-woody vegetation were estimated before treatment applications and in summer 2000. Results were compared to patterns seen in 1994; findings are summarized in the Findings section, below. [Havstad]

In 2001-2003, we designed an experiment that will allow us to use the Stressor Experiment treatments to test the sensitivity of different monitoring indicators to change in the composition and structure of arid grasslands. We hope to eventually relate changes in these simple indicators to more sophisticated soil variability metrics being evaluated by Schlesinger. [Herrick, Havstad]

d. **Fire study:** We examined the effects and interactions of fire and livestock grazing on vegetation community responses in Chihuhuan desert grasslands. Four 200m x 200m plots were established in each of four blocks. Fires were prescribed in June 1999. In October 1999, unfenced plots were exposed to 12 months of continuous grazing; utilization was <40%. Cover was measured before and after 14 months after fire using a vertical line point intercept method every 10cm along five 150m transects within each plot. We also examined black grama response using quadrats. Findings are summarized below.

   In 2001-2002, we resampled these plots and transects. A manuscript is in preparation for submission to a journal for publication. We also participated in a cross-site effort by resampling fire plots established at the SEV LTER following a natural fire in 1998. These plots were established in blue grama and black grama grasslands as well as at their ecotones. We are examining the importance of fire in generating patterns in vegetation at intermediate spatial scales (100-400 m^2). [Havstad, Peters, Drewa]

e. **Fire and consumers:** Field work, data management, and data analysis for animal population studies in the LTER-related fire ecology project were carried out. Species composition and relative abundance were tracked for rodents, grasshoppers, and lizards. [Lightfoot]

   Fire and Lehmann lovegrass: A side project related to the fire study was carried out by a master's student, exploring the interaction between fire and the presence of the invasive grass, Eragrostis lehmanniani. An established patch of the invasive grass in the study pasture was mapped, and plant species composition and abundance was mapped along permanent transects crossing that patch before and after the application of fire; transects were randomly assigned to burn or control treatments. Soil and litter characteristics were also assessed in the lovegrass patch and in native-dominated portions of the transects. [Huenneke, Herrick, McGlone]

   Areas where Lehmann's lovegrass is a major component of the community along with black grama and creosote that were burned as a result of an arson fire in 2000 where resampled and geo-referenced in 2003 [Peters].

4. Investigations capitalizing on the extended history of research at the Jornada (dating back to early 20th century studies)

a. **Re-construction of historical remediation treatments and photographic archive:** Aerial photos to cover the CDRRC and JER ranches have been purchased to assist in the documentation of historical treatments and to evaluate vegetation change. The following years' photography has been acquired: 1935, 1936, 1937, 1947, 1948, 1955, 1960, 1967, 1972, 1973, 1974, 1980, 1986, 1987, and 1991. In particular, imagery of a little-disturbed pasture on the CDRRC was chosen to evaluate the invasion of shrubs and to document changes since 1935 (see description of archival reconnaissance, below). Various land surface discontinuities have been detected and related to file documentation of rangeland remediation treatments. Some treatments located with aerial photography were previously unknown. An initial paper documenting the usefulness of aerial photography for identifying rangeland remediation treatment is now in press. The knowledge of extent and intensity of rangeland remediation treatments is now in press. The knowledge of extent and intensity of rangeland remediation will be used to assist in evaluation of LTER exclosure studies.

   In 2001-2003, we scanned > 3500 historical aerial photos from the JER and CDRRC. Digital files are stored on LTER servers. Currently a search tool is being designed to allow Jornada Basin researchers to determine the availability of historical air photos through time for their study area. Upon completion, the researcher will be able to download compressed or uncompressed files. [Rango, Goslee, Herrick, Havstad, Huenneke]

b. **Archival reconnaissance of mesquite invasion:** Working with supplemental funding derived from the cooperative agreement between NSF and MEDEA, Sarah Goslee (USDA/ARS) and Bill Schlesinger are examining aerial and satellite remote sensing of an area of historical mesquite invasion north of Mount Summerford. The archival record of this photograph allows them to show the pattern of invasion in terms of number and aerial coverage of the shrubs, and to conduct a pattern analysis detailing the process of invasion. Data analysis is largely complete and manuscript preparation is underway.

   In 2001-2002, we completed the analysis of the photos, and published a paper in J. Arid Environments. [Schlesinger, Goslee, Peters, Rango, Havstad]

c. **Resampling of historical lagomorph exposure experiments:** Early in the history of the JER, several large livestock exclosures were established within which shrub removal and lagomorph (rabbit) exclusion treatments were applies. One of these study sites was re-sampled in 1997, and the others were relocated in preparation for resampling in 2001. Preliminary data collected in the 1997 effort indicated that soil C and N was higher in both shrub removal and rabbit exclusion treatments relative to controls, and that there was less gravel in the top 5 cm of the lagomorph exclusion plots. In 2001, we initiated measurements and soil sample collection at all three sites to quantify soil C, N, and aggregate stability.

In 2001-2003, we completed measurements and soil sample collection at all three shrub removal/lagomorph exclusion sites. Soils are now being processed to quantify soil C, N, aggregate stability and bulk density. [Havstad, Herrick]

5. Cross-site work

a. **Small mammal impacts on recruitment of perennial grasses:** 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, consisting of an ecotone between black grama grassland and an alternative dominant species, either creosotebush (SEV), honey mesquite (JRN) or chino grama (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) and one postdoc (Tamara Hochstrasser) are working on this project.

   In 2001-2003, we continued this study by completing cage installations and collecting baseline measurements. We are monitoring black grama basal diameters and assessing plant growth and colonization of all species within each plot. A series of experiments investigating black grama seed predation by rodents and ants, and seedling predation by rodents and lagomorphs are being designed. We are also monitoring small mammal abundance along these ecotones using mark and recapture trapping procedures. [Peters, Bestelmeyer]

b. **US-Hungary collaboration on disturbance effects on grassland diversity patterns:** Debra Peters and Jim Gosz (University of New Mexico) also received funding from NSF Ecological Studies to continue collaborations with a group of ecologist 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 done at sites located 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 south-central 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 investigator 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).

In 2001-2003, we conducted extensive surveys at the Comanche, Kiowa, and Pawnee National grasslands in order to select locations for use in this project. Locations at the JRN and SEV LTER sites are being coordinated with the small mammal cross-site project above. We designed a seed bank study and began characterizing the disturbance regime at each of the 5 sites. We also obtained aerial photos for the national grasslands to assist in location selection and to characterize disturbances. Seed bank samples will be collected starting this fall. [Peters]

c. **Small mammal exclosure study:** Field work and analysis continued for the cross-site project examining the role of small mammals in desert grassland shrubland at three Chihuahuan desert sites (Sevilleta, Jornada, and Mapimi Biosphere Reserve in Mexico). Rodents are trapped outside the exclosure, and vegetation, grasshoppers, and soil surface characteristics are assessed in the exclosure treatments.

In 2001-2003, we continued collecting data from these plots. [Lightfoot]

d. Plant population biology: Field work and data analysis continued on a demographic study of a prickly pear cactus species, tracking populations I both Jornada and Mapimi Biosphere Reserve. A former postdoctoral associate, now a faculty member at UNAM/Instituto de Ecologia, continues work with Huenneke at the Jornada; a manuscript is nearing completion for submission. [Huenneke, Mandujano]

e. Chihuahuan rangeland health and sustainable management: Herrick and Huenneke continue as technical advisors on studies of rangeland ecosystem sustainability administered by researchers at La Campana Experimental Range, Chihuahua (studies funded by CONACyT and by INIFAP).

f. **Monitoring manual:** The "Monitoring Manual for Grassland, Shrubland, and Savanna Ecosystems" will be available through Island Press by late 2002. This document integrates much of the LTER research and applies it to indicator selection and interpretation. The document is already being used by a number of individuals and organizations. Three trainings were provided to agency personnel and private individuals, one each in Chihuahua and Sonora, Mexico, and at the Audubon Ranch in Arizona. We also continue to support the implementation and refinement of the assessment tool, "Interpreting Indicators of Rangeland Health". We will co-lead a 1-day workshop on the use of this manual at the 2002 ESA meetings. Both of these are collaborative efforts with a large number of

individuals and organizations, including the NRCS, USGS, BLM, and the Nature Conservancy.

g. International: Gutschick carried out collaborations (in physiological model development) with French researchers at Montpellier supported by an NSF International Programs supplement.

6. Information Management and Infrastructure

a. **GIS/Spatial database and maps** – see Landscape scale work, above.

In 2001-2003, more digital map layers were created for the USDA-ARS Jornada Experimental Range (JER) infrastructure.. These map layers include the pasture fences, roads, dirt tanks, etc. New geomorphology map layers for the Jornada Basin include organic carbon and carbonate carbon. The SDE geodatabase has been prepared to be loaded into the spatial server. The Spatial Data Laboratory has been set up in the new facility. [Nolen and others]

b. **ArcIMS Project:** The Jornada Basin LTER has been developing a customized ArcIMS implementation to make JRN data and associated metadata more accessible. This application will provide a dynamic, interactive mapping and querying interface to JRN meta-data and research data using both internet and intranet web sites. Ken Ramsey (data manager) and Barbara Nolen (GIS specialist) completed training with Environmental Systems Research Institute (ESRI) for the software applications and system architecture design needed to support, maintain, and enhance the ArcIMS application. In conjunction with the USDA-ARS-Jornada Experimental Range, we are investing in new servers and workstations to support the new application and the integration of data management from LTER and ARS research.

In 2001-2003, Barbara Nolen and Ken Ramsey finalized the scope of work and proposal for the contract with ESRI Implementation Services to develop the ArcIMS application. ESRI will start development later this fall. The database server (SQL 2000, ArcSDE) and the map server (ArcIMS) have been purchased and installed. Two new workstations have been purchased to allow Ken and Barbara to support the ArcIMS application and software. In addition to the training in ESRI software that Barbara and Ken received last year, Ken has attended training for Data Junction (DJ) software suite to allow transcribing JRN ASCII data and metadata files to database and Ecological Metadata Language (EML) formats. EML will provide a standard exchange format for ecological metadata, allowing shared software development by the ecological community at large by allowing applications developed to EML to be easily modified for use by other organizations. The LTER Network Office funded Ken's training with DJ so that Ken could contribute to the ongoing LTER EML Workshops and help those LTER sites that have their data and metadata in ASCII or other text formats to transcribe their metadata into EML format. The ArcIMS project will use EML to

integrate JRN and JER metadata so that other ecological agencies can use our ArcIMS framework being developed. The ArcIMS project is jointly funded by the JRN and JER. [Nolen and Ramsey]

c. **Field Station Connectivity project:** The fiber optic cable has been laid to the Jornada Experimental Range headquarters (HQ) and the phone system (PBX system) is now operational. The T-1 connection to the JER HQ is being finalized in summer 2001, and NMSU is installing the field equipment needed for data connectivity. This will allow JER and LTER researchers and visitors to communicate and upload collected data more readily to campus and elsewhere. We also anticipate this allowing us to explore spread spectrum technology for automated data collection from selected remote instrumentation across the basin. [Havstad, Ramsey]

d. **Data management infrastructure:** With LTER supplemental funds and with additional support from the USDA-ARS, the JRN servers, RAID box, and tape library are now housed in the new network of rack enclosure. This provides a higher degree of physical security as well as protecting the servers and tape library from heat and dust. The new web server and primary domain controller are now operational. The FTP services have been removed from the file server and placed on an older workstation running Netware 5.1 operating system. Two new workstations have been purchased to upgrade the site manager's computer and provide an addition field technician computer. The Jornada LTER bibliography is now searchable over the Internet using ISI Research (ProCite) Reference Web Poster software. The bibliography site can be accessed at http://128.123.5.143/ris or from the Bibliography page accessible from the Jornada LTER home page. The Research Notification table is now queryable over the intranet and accessible to JRN and JER site managers, to aid in research site selection and approval. JRN has purchased a color plotter for the GIS lab as well. These efforts are all aimed at furthering the integration of information management when the LTER site office, laboratory, and staff members move to join the staff of the Jornada Experimental Range in the new USDA-ARS building now under construction on the NMSU campus. [Ramsey, Anderson, Nolen]

e. **Upgrading of soil thermocouples for climate data:** The Jornada LTER weather station has been in place long enough that some systems have failed or come to need upgrading. Soil temperature measurements had become problematic in recent year, necessitating replacement of soil thermocouples. Gutschick worked with the site manager John Anderson to test the reinstalled soil thermocouples. Following modification of the reference junction, the signals were found to be consistent with past data and with predictions of heat-transport theory. To replace the infrared bolometer that failed after 15 years of service, Gutschick designed a drift-free, permanently calibrated system using infrared thermocouples.

f. **New in 2001-2002:**

Network and systems: The JRN site offices moved to the new USDA-ARS Jornada Experimental Range (JER) building on NMSU's campus in 2002. This includes offices for the Site Manager, Data Manager, GIS specialist, and 3 full-time technicians as well as laboratory facilities and services for use by LTER staff and researchers.

One benefit of the move is that the JRN servers and rack enclosure have been integrated with the JER servers and racks to create a distributed networking environment. The JRN and JER network are now behind a firewall for additional security. The servers are now located in an environmentally controlled room. In addition to sharing network, computer, and printer resources, JRN and JER are now sharing another important resource, computer support personnel. Both the JRN and JER will benefit from sharing of these resources and the ArcIMS project. By sharing personnel and infrastructure resources, we build on the excellent working relationship that the JRN and JER have enjoyed in the past and reduce future costs for both organizations.

7. Meetings and Presentations:

2000-2001

All Scientists' Meeting, LTER Network, Snowbird, UT, Summer 2000. Curtis Monger spoke at a landscape-scale workshop and at a symposium on ecosystem responses to climate change. Huenneke andLightfoot both spoke in the GCTE species removal workshop; Huenneke helped organize a workshop on invasive species research at LTER sites; Goslee presented the satellite photo reconnaissance of shrub recruitment; Peters' Hungarian collaboration and cross-site SEV-JRN ecotone study were both presented; Peters and Herrick presented their work on plant-soil feedbacks and recruitment constraints on perennial grass recovery following shrub invasion; Peters organized several workshops on integrating ecological studies at the landscape scale.

Ecological Society Meeting, Snowbird, UT, summer 2000. Contributed papers and posters:

Davidson, A.D., D.C. Lightfoot, and J.S. Gosz. Comparative effects of Gunnison's prairie dogs and banner-tailed kangaroo rats on plants and grasshoppers in a semi-arid grassland.

Goslee, S.C., D.P.C. Peters, K.A. Havstad, and W.H. Schlesinger. Shrub recruitment and survival in desert grasslands.

Herrick, J.E., J. Van Zee, A. Melgoza, K.M. Havstad, and W. G. Whitford. Integrated soil and vegetation monitoring for grassland, shrubland, and savanna ecosystems.

Hochstrasser, T., and D.P.C. Peters. Effects of shrubs and disturbances on pattern and process in Chihuahuan Desert grasslands.

Kroel-Dulay, G., T. Hochstrasser, and D.P.C. Peters. The influence of kangaroo rat mounds on species diversity and abundance in two grassland types at a semi-arid ecotone.

Lightfoot, D.C., and L.F. Huenneke. The effects of livestock grazing and climate variation on vegetation and grasshoppers in the northern Chihuahuan Desert.
Peters, D.P.C. Plant species dominance and disturbance at a grassland-shrubland ecotone.

Bestelmeyer, S., P. Hyder, E. Fredrickson, K. Havstad, J. Herrick, L. Huenneke, and J. Atchley. K-12 environmental science education on the US-Mexican border.

Huenneke, L.F., M. Muonopane, L. Bothern, and J.E. Herrick. Effects of plant removals on soil surface erosion in a Chihuahuan Desert shrubland.

Gutschick and A. Bloom are organizing a symposium for the 2001 ESA meeting, entitled "Crossroads of animal, plant, and microbial ecology", encouraging communication among the fields of animal, plant, and microbial ecophysiology.

Monger, invited talk at the Soil Science Society of America (Minneapolis, Nov. 2000).

Monger, invited talk seminar at Texas A&M Univ. (College Station, Feb. 2001).

Monger, invited talk at the National Cooperative Soil Survey (Ft. Collins, June 2001) (also co-chaired the Research Needs Committee).

Peters organized and Monger attended the Landscape Scale Workshop at the Sevilleta field station in April 2001.

ASA-CSSA-Soil Science Society of America annual meeting, 2000: Herrick was author or co-author on three presentations.

Herrick was invited keynote speaker ("Monitoring methodology for pasture degradation and restoration") in the International Symposium on Silvo-pastoral Systems, San Jose, Costa Rica, April 2001.

2001-2002

17th Annual International Association for Landscape Ecology meetings in Lincoln, NE (April 2002).

Peters organized a symposium entitled, Current landscape scale issues in ecology: the right tools for the job. Invited papers by JRN scientists:

Brown, J. R., and K. M. Havstad. Remediating degraded ecosystems: complications of scale.

Lane, D. R., B. B. Bestelmeyer, K. A. Mitchell, W. J. Parton. Simple and weighted averaging approaches to scaling: When can spatial context be ignored?

Mitchell, K. A., D. D. Breshears, C. Allen, B. B. Bestelmeyer, J. E. Gross. Scaling Approaches Across Ecological Disciplines: Case Studies of Vegetation, Soil and Animal Dynamics.
Peters, D. P. C., and D. L. Urban. Introduction: Approaches to scaling information from plots to landscapes or from landscapes to regions.

Contributed papers and posters:
Mitchell, K. A., D. P. C. Peters, H. C. Monger, and J. E. Herrick. Quantifying Changes in Carbon Cycling Accompanying Shrub Invasion of a Desert Grassland.

Hochstrasser, T., D. P. C. Peters, and B. T. Bestelmeyer. Simulating small mammal effects on grass-shrub ecotones in arid ecosystems.

Yao, J., D. P. C. Peters, K. M. Havstad, R. P. Gibbens, and J. E. Herrick. Spatial variation in shrub invasion and loss of perennial grasses in the Chihuahuan Desert: a multi-scale approach.

International presentations:
Gillette, LISA (Laboratoire Interuniversitaire des Systemes Atmospheriques), Paris, France. Seminar: AMesquite, le lyon du desert.@

Herrick, invited plenary talk ("Ecological state and transition models: a new framework for monitoring soil erosion in the context of socioeconomic change") in the Soil Erosion and Global Change Workshop, Brussels, Belgium, March 7-9.

Monger, invited talk at the XIII Semana Internacional de Agronomia in Gomez Palacio, Mexico.

Rango, talk entitled "ASTER observations of surface emissivity" at the European Geophysical Society, General Assembly, Nice France, 26-30 March.

Ecological Society of America meetings, Madison, WI. August 2001:
Buonopane, M.A., L.F. Huenneke, and M.D. Remmenga. Plant functional group response to plant removal treatments in a Chihuahuan Desert shrubland.

Herrick, J.E., J. Belnap, J. Van Zee and J. Johansen. Disturbance effects on infiltration and erosion susceptibility for biologically crusted soils in the Mojave Desert.

Peters, D. P. C., and J. Betancourt. Climatic triggers for non-linear and threshold responses of rangelands. Invited paper in the symposium, Threshold and non-linear responses in ecosystems: understanding, sustaining and restoring complex ecosystems.

Ritchie, J.C. and Herrick, J.E. Using cesium-137 to understand landscape stability in the northern Chihuahuan Desert.

Herrick co-organized the symposium, Threshold and non-linear responses in ecosystems: understanding, sustaining and restoring complex ecosystems.

Other national meetings:
Herrick, J.E., A.J. Tugel, M.D. Remmenga, L.M. Myers, L.M. Norfleet, C. Ditzler. 2001. Spatial variability in dynamic soil properties: sampling requirements for a national soil database. Soil Science Society of America Annual Meetings, Charlotte, North Carolina.

Van Zee, J.W. and J.E. Herrick. 2001. A portable rainfall simulator for small, paired-plot simulations. Soil Science Society of America Annual Meetings, Charlotte, North Carolina.

Herrick, J.E. 2002. Research requirements for applying soil quality to sustainable land management. Soil Quality: Current Challenges and Emerging Perspectives symposium and the Western Society of Soil Science Meetings, Ft. Collins, CO, June 3-5 (invited symposium presentation).

Herrick, J.E. 2002. Rangeland integrity: how do we know? The Nature Conservancy Arid Lands Network Workshop, Las Cruces, NM, May 20-23 (invited plenary session presentation).

Schmugge, T., French, A., Ritchie, J., Chopping, M., and Rango, A. 2001. ASTER observations of the spectral emissivity over New Mexico. Geophysical Research Abstracts, Volume 3, 2001, Abs. 3291, 26-30 March, 2001, on cd-rom (Abstract)

Chopping, M.J., Rango, A., and Gomez-Landesa, E. 2002, The importance of early morning local overpass times for BRDF retrieval, modeling of spectral reflectance and *fAPAR* estimation. Proceedings of the Intl. Geoscience & Rem. Sens. Symposium Vol. IV: 2264-2266.

Chopping, M.J., Rango, A., Goslee, S., Schmugge, T., and Ritchie, J. Simulation of a grassland-shrubland transition zone landscape image at 650 nm using a simple BRDF model. Proceedings of IGARSS Vol. VI: 3561-3563.

2002-2003

Laura Huenneke and Deb Peters travled to southern Africa in July (2002) as part of a group sponsored by the LTER Network office. They discussed LTER with researchers in Namibia (Huenneke) and Botswana (Peters) prior to attending the first ELTOSA (Environmental Long Term Observatories Network of Southern Africa) conference on Inhaca Isalnd, Mozambique. Peters has been invited to attend the second ELTOSA conference in Maun, Botswana in Oct. 2003.

Vince Gutschick represented the Jornada LTER at the European-American workshop on Long Term Socio-Environmental Research. The meeting, held in Lotz, Haute Savoie, France from July 1-5, 2003, brought together approximately 25 US LTER researchers and 25 European researchers who were mostly associated with ILTER sites. The goal was to generate long term collaborations, which would infuse US LTER research with a significant component of socio-economic research, particularly focused on land use and its attendant drivers.

Tony Parsons attended the IGU Regional conference in Durban (2002), and presented the paper, "Geomorphological processes and biogeochemical cycles in mesquite dunefields, southern New Mexico.

Tony Parsons attended the EGS-AGU-EUG Joint Assembly in Nice (2003), and presented the papers, "Sampling interrill water, sediment, and nutrient fluxes across vegetation boundaries in the Jornada Basin, New Mexico" (A. J. Parsons, J. Wainwright, D. M. Powell, and R. Brazier) and posters "Parameter scaling of key hydrological soil-erosion, and nutrient parameters in an arid desert ecosystem" (E. N. Muller, J. Wainwright, and A. J. Parsons) and "Geomorphological processes and biogeochemical cycles in mesquite dunefields, southern New Mexico" (A. J. Parsons and J. Wainwright).

8. Other Activities

a. **Site synthesis volume:** After a hiatus during which we submitted the renewal proposal and organized the first year of work under the new funding cycle, we have resumed active work on our synthesis volume. Huenneke took the lead in editorial activities as Schlesinger assumed responsibility for covering key additional content. The book will be submitted to the LTER Network office in Sept. (2003).

b. **Graduate course:** As anticipated in our renewal proposal, Monger and Huenneke offered a graduate seminar course at NMSU in 2001 ("Chihuahuan Desert Ecosystems"). Ten students from a wide range of basic and applied science departments read classic and current literature from Jornada studies and engaged in discussions with many Jornada LTER researchers.

c. **Workshops organized:**

2000-2001:

Peters organized a workshop at the SEV field station, April 2001, on scaling information from plots to landscapes and regions. Funded by the LTER Network Office.

2001-2002

Huenneke organized a GCTE workshop in Las Cruces, NM, August 2001, entitled "Ecosystem consequences of species removals". Funded by the LTER Network Office.

Huenneke organized an NCEAS working group, April 2002, entitled "Analysis of diversity reduction experiments to address the ecosystem consequences of biodiversity loss".

9. Associated grant and contract funding

Monger, H.C. (with T.L. Jones and G.A. Kidron). International Arid Lands Consortium, "Factors controlling microbiotic crusts: Negev and New Mexico." $75,000, 2000-2002.

Monger, H.C. and J.E. Herrick. USDA National Research Initiative competitive grants program, "CO2 emissions from the dissolution of soil carbonate as a contributor to greenhouse gases." $142,500. 2000-2003.

Gillette, D. (with A. Pitchford). US Army Center for Health Promotion and Preventative Medicine. "PM10 and sand fluxes from mesquite-dominated landscapes."

Herrick, J.E. US Dept. of Defense, "Calibration, testing, and implementation of an ecosystem monitoring protocol for military lands." $110,000. 2000-2001.

Herrick, J.E. (with J. Belnap and D. Pyke). "Monitoring protocols for soil stability at the Lake Mead Recreational Area." $44,000. 2000-2001.

Herrick, J.E. Dept. of Defense subcontract from John Carroll University, "Cryptogam study, disturbance effects on soil water infiltration and erosion." $18,975. 2000.

Huenneke, L.F., (with S. Diaz, and F.S. Chapin). LTER Network Office, Post-All Scientists meeting workshop on diversity reduction experiments. $6,000. Workshop held in Las Cruces, NM, August 2001.

Peters, D.P.C. LTER Network Office, Post-All Scientists meeting workshops on scaling information from plots to landscapes and regions. $15,000. Workshops held at the SEV field station and Albuquerque, NM.

Monger, H.C., J.E. Herrick, D.P.C. Peters, and J.T. Harrington. US EPA, "Carbon sequestration potential of southwestern rangelands." $623,600. 2001-2002.

Peters, D.P.C. National Science Foundation, LTER Cross-site program, "Regional variation in direct and indirect influences of animals on Chihuahuan Desert grasslands." $200,000. 2001-2004.

Peters, D.P.C. and K.M. Havstad. US Army Construction Engineering Research Lab, "Prediction of future plant community dynamics for military installations using simulation modeling." $149,036. 2001-2003.

Peters, D.P.C. (with J.R. Gosz). National Science Foundation, "US-Hungary grassland comparisons: Biodiversity, disturbance, and landscape mosaics." $149,229. 2001-2004.

Huenneke, L.F., (with S. Diaz, and F.S. Chapin). National Center for Ecological Analysis and Synthesis (NCEAS), Working group: Analysis of diversity reduction experiments to address the ecosystem consequences of biodiversity loss. $38,000. 2002-2003.

Huenneke, L.F. National Science Foundation, LTER Supplement to the JRN. $52,000. 2002.

Findings:

Jornada LTER results have confirmed and extended our understanding of the general conceptual model of increasing resource heterogeneity as the primary (and self-reinforcing) mechanism of desertification where shrublands displace semi-arid grasslands. Ongoing experiments have documented **the stability (inertia) lent to the system by shrub dominance**. An important result being reinforced by several different studies is that **the small-scale interaction of plant with transport vector (wind or water) scales up not just additively, but in a spatially-explicit manner, to determine the overall export from a landscape unit.** For example, the microtopography of shrub mounds and hummocks interacts with stemflow, throughfall, and runoff processes in creosotebush bajadas to influence formation of rills and channel flow; the compass orientation of mesquite dunes and geometry of bare areas or "streets" are crucial to the generation of dust from mesquite sites.

Our intensified monitoring of dust generation from a network of sites confirms that mesquite sites are the most significant sources of material capable of being transported long distances. Recovery and digitization of old vegetation and soil maps, along with most recent vegetation mapping and current geomorphological mapping, permits us to identify specific locations where vegetation changes have been either more rapid or less rapid than typical – therefore particularly important areas for research into processes facilitating or inhibiting change. Hence our work confirms that **integration of multiple spatial scales (especially that of the landscape) is essential to understanding the consequences of desertification and to predicting future ecosystem dynamics.**

Disturbance studies at the Jornada are illustrating that **in many cases only a small number of species are capable of rapid response to perturbation** (e.g., the plant diversity experiment). Long-term manipulations and our relocation of historical research sites have dramatically highlighted that **observations over a very long period are necessary to see any response, or to distinguish between responsive and non-responsive points on the landscape** (e.g., relocations of CCC remediation treatments from the 1930's). Further, species-level characteristics do determine the capacity of the system to tolerate or to recover from disturbance (soil surface disturbance experiments, responses of native and non-native plants to fire study). Disturbances possess inherent variability that contributes to the heterogeneous nature of plant communities (e.g., fire and acute grazing in the stressor study). Acute forms of disturbance constitute extreme events that can greatly influence structure and function of plant communities. Results of current experiments confirm our previous understanding that **initial conditions (or environmental conditions present at the time of disturbance) pose important constraints to system response.** For example, favorable precipitation patterns immediately following a burn treatment appear to account for the rather strong recovery of both woody and herbaceous species in the fire study. Historical accounts of black grama sensitivity to fire have only been supported if a drought occurs following the burn. Rapid response following a fire is possible for this species under conditions of above-average rainfall during the growing season of the burn.

Long-term studies of aboveground net primary production in a network of sites demonstrate the difficulty of assessing differences across sites or across years when there is so much spatial and temporal heterogeneity within a single site. It would appear that many reports in the literature are based on sampling too limited to permit statistical comparison. Results from long-term monitoring also highlight the individualistic responses of major groups of organisms to climatic variation. For example, rodent and rabbit populations declined in 2000, but increased dramatically during the winter and spring of 2001 in both black grama grassland and creosotebush environments. In contrast, lizard populations decreased across all habitats in 2000, and have not demonstrated an increase, while ground-dwelling arthropod densities remained relatively constant over the same period of time.

Long-term monitoring of quadrats since as early as 1915 **shows tremendous spatial variation in the persistence of perennial grasses against shrub invasion**. Out of 57 original black grama quadrats examined, black grama went extinct before the 1950's drought in 11 quadrats. This species went extinct in 37 quadrats during the 1950's drought, but persisted until 1979 in 9 quadrats. Out of the numerous environmental factors examined, distance to shrub-dominated communities when the quadrat was established, soil sand content, and variation in rainfall were the best predictors of black grama persistence. Basal areas of black grama, mesa dropseed, and tobosa were correlated with long-term annual precipitation whereas annual growth rates of these species were correlated with short-term rainfall occurring in the previous 15 months.

Our carbon sequestration studies show that **most carbon at the Jornada LTER occurs below ground**. Ancient soils with highly-developed petrocalcic horizons, like those at the Stressor Site, have up to 223 kg C m^{-2} (a carbon content that rivals many peat bogs). A comparison of three black grama grassland and three mesquite shrubland sites (Table 1) reveals that **grasslands have less aboveground, root, and soil organic carbon, but more inorganic carbon**. These inorganic differences are probably more a function of soil age differences than ecosystem differences. Although there is evidence that bacteria, fungi, and roots precipitate some of the carbonate in Jornada soils, there is no evidence that termites precipitate carbonate as previously hypothesized. It was hypothesized that termites precipitate carbonate for use as a cementing agent in the construction of their above-ground galleries because (1) many calcareous galleries existed on noncalcareous topsoil and (2) crystals with optical properties similar to carbonate are common in termites. However, chemical mapping with electron microscopy and isotopic studies indicate that termites mine existing carbonate from subsoil horizons rather than forming it themselves. Termites, therefore, play a smaller role in carbon sequestration than they otherwise would have had they routinely biomineralized carbonate in arid ecosystems.

Table 1. Carbon in three grassland and three shrubland sites. Comparison of soil and root carbon is to a depth of 75 cm at each site.

	Black Grama grassland	Mesquite duneland
	kg C m^{-2}	kg C m^{-2}
Above-ground carbon	0.15 ± 0.03	1.08 ± 0.52
Root carbon	0.90 ± 0.01	3.27 ± 1.80
Soil organic carbon	3.25 ± 0.27	4.89 ± 0.32
Soil inorganic carbon	18.92 ± 12.30	9.98 ± 5.12

Finally, early stages of conceptual and simulation model development have been valuable in formulating research priorities for simulation as well as empirical work on plant-soil interactions. The model highlights **the potential constraints on vegetation response to climatic influences posed by propagule availability and by soil limitations on plant recruitment.** Ongoing work is aimed at understanding soil-plant-resource interactions as well as individual components such as plant recruitment and soil dynamic properties.