Annual Report for Period: 11/2006 - 10/2007
Submitted on: 08/04/2007
Principal Investigator: Peters, Debra P.
Award ID: 0618210
Organization: New Mexico St University
Title:
Jornada Basin LTER V: Landscape Linkages in Arid and Semiarid Ecosystems

Project Participants

Senior Personnel

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

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

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

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

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

Name: Archer, Steven
Worked for more than 160 Hours: Yes
Contribution to Project:
Co-PI working on shrub invasion dynamics and belowground carbon

Name: Sala, Osvaldo
Worked for more than 160 Hours: Yes
Contribution to Project:
CO-PI working on NPP patterns and dynamics

Name: Fredrickson, Ed
Worked for more than 160 Hours: Yes
Contribution to Project:
Co-PI working on animal population dynamics

Name: Throop, Heather
Worked for more than 160 Hours: Yes
Contribution to Project:
Co-PI working on soil organic matter dynamics

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

Co-PI working on plant-soil interactions and remediation studies

Name: Gutshick, Vincent
Worked for more than 160 Hours: Yes
Contribution to Project:
Co-PI working on ecophysiology of shrubs

Name: Parsons, Anthony
Worked for more than 160 Hours: Yes
Contribution to Project:
Co-PI working on hydrology studies

Name: Wainwright, John
Worked for more than 160 Hours: Yes
Contribution to Project:
Co-PI working on hydrology modeling

Name: Rango, Al
Worked for more than 160 Hours: Yes
Contribution to Project:
Co-PI working on remote sensing studies

Name: Schlesinger, William
Worked for more than 160 Hours: Yes
Contribution to Project:
Co-PI working on nitrogen and biogeochemical cycling

Name: Okin, Gregory
Worked for more than 160 Hours: Yes
Contribution to Project:
Co-PI working on wind erosion-deposition studies and modeling

Name: Skaggs, Rhonda
Worked for more than 160 Hours: Yes
Contribution to Project:
Co-PI working on human demographic-economic studies

Post-doc

Name: Steele, Caiti
Worked for more than 160 Hours: Yes
Contribution to Project:
working with Brandon Bestelemyer on remote sensing studies; supported by BLM

Name: Rios Casanova, Leticia
Worked for more than 160 Hours: Yes
Contribution to Project:
working with Bestelmeyer on ants and ecotones

Graduate Student

Name: Rachal, David
Worked for more than 160 Hours: Yes
Contribution to Project:
NMSU PhD student with Monger on geomorphology and wind studies 2007 -

Name: Weems, Stacey

Worked for more than 160 Hours: Yes

Contribution to Project:

NMSU MS student working with Monger on banded vegetation formation

Name: Riggs, Justin

Worked for more than 160 Hours: Yes

Contribution to Project:

NMSU MS student working with Monger on soil studies

Name: Adhikari, Pradip

Worked for more than 160 Hours: Yes

Contribution to Project:

NMSU MS student working with Monger on soil studies

Name: Cruz, Janella

Worked for more than 160 Hours: Yes

Contribution to Project:

NMSU MS student working with Monger on soil studies

Name: Campanella, Andrea

Worked for more than 160 Hours: Yes

Contribution to Project:

NMSU PhD student working with Bestelmeyer on plant-animal interactions across ecotones

Name: Goolsby, Darroc

Worked for more than 160 Hours: Yes

Contribution to Project:

NMSU PhD student working with Bestelmeyer on landscape survey

Name: Calkins, Michael

Worked for more than 160 Hours: Yes

Contribution to Project:

NMSU MS student working with Throop on decomposition studies

Name: Kuok Choy, Lam

Worked for more than 160 Hours: Yes

Contribution to Project:

Univ Sheffield PhD student working with Parsons and Wainwright

Name: Klass, Jeremy

Worked for more than 160 Hours: Yes

Contribution to Project:

NMSU PhD student working with Peters on ecotone studies

Undergraduate Student

Name: Adhikari, Pradip

Worked for more than 160 Hours: Yes

Contribution to Project:

working with Bestelmeyer on landscape survey and soil studies

Name: Romig, Kirsten

Worked for more than 160 Hours: Yes

Contribution to Project:

working with Bestelmeyer on plant inventories

Name: Sprague, Jesse

Worked for more than 160 Hours: Yes
Contribution to Project:
working with Throop on soil organic matter studies

Name: Meyer, Nichole
Worked for more than 160 Hours: Yes
Contribution to Project:
working with Throop on decomposition studies

Name: Chisala, Ngawina Veronic
Worked for more than 160 Hours: Yes
Contribution to Project:
working with Throop on decomposition studies

Name: Reichmann, Lara
Worked for more than 160 Hours: Yes
Contribution to Project:
Brown University PhD student working with Sala on ANPP and rainfall study

Name: Midez, Jaime
Worked for more than 160 Hours: Yes
Contribution to Project:
assisting Sala on rainout shelters

Name: De Lao, Cheryl Maria
Worked for more than 160 Hours: Yes
Contribution to Project:
working with Monger on soil studies

Technician, Programmer

Name: Burkett, Laura
Worked for more than 160 Hours: Yes
Contribution to Project:
GIS analyst working with Bestelmeyer

Name: Van Zee, Justin
Worked for more than 160 Hours: Yes
Contribution to Project:
project manager for Herrick's plant-soil studies and monitoring research

Name: Anderson, John
Worked for more than 160 Hours: Yes
Contribution to Project:
Site manager for Jornada Basin LTER

Name: Nolen, Barbara
Worked for more than 160 Hours: Yes
Contribution to Project:
Spatial database expert for Jornada Basin LTER (50% NSF, 50% ARS)

Name: Ramsey, Ken
Worked for more than 160 Hours: Yes
Contribution to Project:
Information manager for the Jornada Basin LTER

Name: Kuehner, John

Worked for more than 160 Hours: Yes

Contribution to Project:
LTER field crew technician

Name: Huang, Haitao

Worked for more than 160 Hours: Yes

Contribution to Project:
computer programmer working with Peters on ECOTONE model

Name: Toledo, David

Worked for more than 160 Hours: Yes

Contribution to Project:
worked with Bestelmeyer and Herrick on soil sampling

Name: Laney, Christine

Worked for more than 160 Hours: Yes

Contribution to Project:
Coordinator for EcoTrends project

Name: James, Darren

Worked for more than 160 Hours: Yes

Contribution to Project:
assists in field sampling and lab analyses

Name: Crossland, Keith

Worked for more than 160 Hours: Yes

Contribution to Project:
working with Herrick on field data collection and lab analyses

Name: Courtright, Ericha

Worked for more than 160 Hours: Yes

Contribution to Project:
project manager for Herrick's soil and monitoring studies

Name: Slaughter, Amy

Worked for more than 160 Hours: Yes

Contribution to Project:
working with LTER scientists on field data collection

Name: Tucker Britt, Chandra

Worked for more than 160 Hours: Yes

Contribution to Project:
member LTER field crew

Name: Wang, Mei

Worked for more than 160 Hours: Yes

Contribution to Project:
LTER lab technician working for Monger

Other Participant

Name: Laliberte, Andrea

Worked for more than 160 Hours: Yes

Contribution to Project:
collaborator on remote sensing studies

Name: Whitford, Walt

Worked for more than 160 Hours: Yes

Contribution to Project:

working with LTER scientists on small animal studies

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 funded by NSF and external funding

Name: Brown, Joel

Worked for more than 160 Hours: Yes

Contribution to Project:

working with LTER scientists on carbon sequestration issues (NRCS)

Name: Tugel, Arlene

Worked for more than 160 Hours: Yes

Contribution to Project:

working with LTER scientists on soil studies (NRCS)

Name: Belnap, Jayne

Worked for more than 160 Hours: Yes

Contribution to Project:

working with Herrick on soil surface disturbance studies (USGS)

Name: Bleiweiss, Max

Worked for more than 160 Hours: Yes

Contribution to Project:

working with Al Rango on assembling high resolution satellite data base

Name: Brazier, Richard

Worked for more than 160 Hours: Yes

Contribution to Project:

working with Parsons and Wainwright on hydrology studies (Univ Sheffield)

Name: Kustas, Bill

Worked for more than 160 Hours: Yes

Contribution to Project:

working with Rango on JORNEX project (ARS)

Name: Pyke, Dave

Worked for more than 160 Hours: Yes

Contribution to Project:

working with Herrick on soil and vegetation monitoring

Name: Schmugge, Tom

Worked for more than 160 Hours: Yes

Contribution to Project:

working with Rango on JORNEX project

Name: Yarnes, Christopher

Worked for more than 160 Hours: Yes

Contribution to Project:

working with LTER scientists to analyze soil samples in the LEC lab at NMSU

Name: Roemer, Gary

Worked for more than 160 Hours: Yes

Contribution to Project:
working with Bestelmeyer on plant-animal studies across ecotones

Name: Ulery, April
Worked for more than 160 Hours: Yes
Contribution to Project:
working with Herrick and Monger on soil chemical properties

Name: Collins, Scott
Worked for more than 160 Hours: Yes
Contribution to Project:
working with Peters on cross-site studies of ecotones

Name: Gosz, James
Worked for more than 160 Hours: Yes
Contribution to Project:
working with Peters on cross-site ecotone studies

Research Experience for Undergraduates

Name: Sanders, Brandon
Worked for more than 160 Hours: Yes
Contribution to Project:
working with Bestelmeyer on soil studies

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: 2007
REU Funding: REU supplement

Name: Ebbs, Lisa
Worked for more than 160 Hours: Yes
Contribution to Project:
working with Throop on belowground studies

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: 2007
REU Funding: REU supplement

Name: Johnson, Eric
Worked for more than 160 Hours: Yes
Contribution to Project:
Brown University REU student working with Sala on ANPP and rainfall study

Years of schooling completed: Other
Home Institution: Other than Research Site
Home Institution if Other: Brown University
Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree
Fiscal year(s) REU Participant supported: 2007
REU Funding: REU supplement

Name: Ricketts, Sarah

Worked for more than 160 Hours: Yes

Contribution to Project:

working with Monger on soil studies

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: 2007

REU Funding: REU supplement

Organizational Partners

USDA ARS JER

Houses Jornada Basin LTER main office and laboratories. Provides salary for lead PI and ARS scientists working on the LTER. Collaborative research with other ARS scientists.

Chihuahuan Desert Nature Park

The CDNP is our partner in K-gray educational outreach programs. The CDNP coordinates the Schoolyard LTER program with schools in the region, operates field trips and classroom visits to relate LTER science to students and teachers, direct summer workshops for regional science teachers, and conducts on-site events for the public.

USDA NRCS

Provides collaborative research through activities of Joel Brown and Arlene Tugel, NRCS scientists housed in the same building as the LTER.

USDI BLM

Provides collaborative research on state-and-transition models (Bestelmeyer) and monitoring of vegetation and soils (Herrick, Havstad).

University of Sheffield

Office space, computer, and salary support to Parsons and Wainwright.

Brown University

Provides office space, computers, and salary for Sala and his students.

University of California at Los Angeles

Provides office space, computers, and salary support for Okin and his students.

Duke University

Provides office space, computers, and salary support to Schlesinger (2006-07).

University of Arizona

Provides office space, computers, and salary support to Archer and his students.

Other Collaborators or Contacts

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

The Nature Conservancy, Las Cruces office: conservation planning.

UNAM: collaborations with scientists at the Mapimi Biosphere reserve, Mexico.

INIFAP: collaborations with Dr. Alicia Melgoza in Chihuahua, Mexico.

Institute of Ecology and Botany, Vacratot, Hungary: collaborations with Drs. Edit Kovacs Lang and Gyuri Kroel Dulay.

CARSAME (Center for Applied Remote Sensing in Agriculture, Meteorology, and the Environment): collaborations with Dr. Max Bleiwess.

INRAM (Institute for Natural Resource Analysis and Management): NMSU lab for equipment and soil analyses.

University of New Mexico: collaborations with Scott Collins and others on cross-site research.

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:
Teacher training workshops each summer directed by the Chihuahuan Desert Nature Park, including participation by LTER scientists.

Outreach Activities:
see Activities file

Journal Publications

Abrahams, AD; Gao, P, "A bed-load transport model for rough turbulent open-channel flows on plane beds", EARTH SURFACE PROCESSES AND LANDFORMS, p. 910, vol. 31, (2006). Published, 10.1002/esp.130

Beever, EA; Swihart, RK; Bestelmeyer, BT, "Linking the concept of scale to studies of biological diversity: evolving approaches and tools", DIVERSITY AND DISTRIBUTIONS, p. 229, vol. 12, (2006). Published, 10.1111/j.1366-9516.2006.00260.

Bestelmeyer, BT, "Threshold concepts and their use in rangeland management and restoration: The good, the bad, and the insidious", RESTORATION ECOLOGY, p. 325, vol. 14, (2006). Published,

Bestelmeyer BT; Khalil NI; Peters DPC, "Does shrub invasion indirectly limit grass establishment via seedling herbivory? A test at grassland-shrubland ecotones.", Journal of Vegetation Science, p. 363-370, vol. 18, (2007). Published,

Bestelmeyer, BT; Ward, JP; Havstad, KM, "Soil-geomorphic heterogeneity governs patchy vegetation dynamics at an arid ecotone", ECOLOGY, p. 963, vol. 87, (2006). Published,

Bestelmeyer BT; Ward JP; Herrick JE; Tugel AJ, "Fragmentation effects on soil aggregate stability in a patchy arid grassland.", Rangeland Ecology and Management, p. 406-415, vol. 59, (2006). Published,

Bowker, GE; Gillette, DA; Bergametti, G; Marticorena, B, "Modeling flow patterns in a small vegetated area in the northern Chihuahuan Desert using QUIC (Quick Urban & Industrial Complex)", ENVIRONMENTAL FLUID MECHANICS, p. 359, vol. 6, (2006). Published, 10.1007/s10652-005-6021-

Bird SB; Herrick JE; Wander MM; Murray L, "Multi-scale variability in soil aggregate stability: implications for understanding semiarid grassland degradation.", Geoderma, p. 106-118, vol. 140, (2007). Published,

Brazier RE; Parsons AJ; Wainwright J;Powell DM; Schlesinger WH, "Upscaling understanding of nutrient dynamics associated with overland flow in semi-arid environments", Biogeochemistry, p. 265-278, vol. 82, (2007). Published,

Chapin, FS; Woodwell, GM; Randerson, JT; Rastetter, EB; Lovett, GM; Baldocchi, DD; Clark, DA; Harmon, ME; Schimel, DS; Valentini, R; Wirth, C; Aber, JD; Cole, JJ; Goulden, ML; Harden, JW; Heimann, M; Howarth, RW; Matson, PA; McGuire, AD; Melillo, JM; Moon, "Reconciling carbon-cycle concepts, terminology, and methods", ECOSYSTEMS, p. 1041, vol. 9, (2006). Published, 10.1007/s10021-005-0105-

Crisci, JV; Sala, OE; Katinas, L; Posadas, P, "Bridging historical and ecological approaches in biogeography", AUSTRALIAN SYSTEMATIC BOTANY, p. 1, vol. 19, (2006). Published, 10.1071/SB0500

Darby, BJ; Housman, DC; Zaki, AM; Shamout, Y; Adl, SM; Belnap, J; Neher, DA, "Effects of altered temperature and precipitation on desert protozoa associated with biological soil crusts", JOURNAL OF EUKARYOTIC MICROBIOLOGY, p. 507, vol. 53, (2006). Published, 10.1111/j.1550-7408.2006.00134.

Dobson, A; Lodge, D; Alder, J; Cumming, GS; Keymer, J; McGlade, J; Mooney, H; Rusak, JA; Sala, O; Wolters, V; Wall, D; Winfree, R; Xenopoulos, MA, "Habitat loss, trophic collapse, and the decline of ecosystem services", ECOLOGY, p. 1915, vol. 87, (2006). Published,

Dunway MC; Herrick JE; Monger HC, "The water-holding capacity of petrocalcic horizons", Soil Science Society of America Journal, p. 812-819, vol. 71, (2007). Published,

Flombaum P; Sala OE, "A non-destructive and rapid method to estimate biomass and aboveground net primary production in arid environements.", Journal of Arid Environments, p. 352-358, vol. 69, (2007). Published,

Gillette, DA; Herrick, JE; Herbert, GA, "Wind characteristics of mesquite streets in the northern Chihuahuan Desert, New Mexico, USA", ENVIRONMENTAL FLUID MECHANICS, p. 241, vol. 6, (2006). Published, 10.1007/s10652-005-6022-

Gutschick VP, "Plant acclimation to elevated CO2 - from simple regularities to biogeographic chaos.", Ecological Modelling, p. 433-451, vol. 200, (2007). Published,

Herrick JE; Sarukhan J, "A strategy for ecology in an era of globalization.", Frontiers in Ecology and the Environment, p. 172-181, vol. 5, (2007). Published,

Herrick JE; Schuman GE; Rango A, "Monitoring ecological processes for restoration projects", Journal for Nature Conservation, p. 161-171, vol. 14, (2006). Published,

Howes, DA; Abrahams, AD; Pitman, EB, "One- and two-dimensional modelling of overland flow in semiarid shrubland, Jornada basin, New Mexico", HYDROLOGICAL PROCESSES, p. 1027, vol. 20, (2006). Published, 10.1002/hyp.592

Hu, SX; Abrahams, AD, "Partitioning resistance to overland flow on rough mobile beds", EARTH SURFACE PROCESSES AND LANDFORMS, p. 1280, vol. 31, (2006). Published, 10.1002/esp.133

Mueller EN; Wainwright J; Parsons AJ, "The impact of rain on the modelling of overland flow within semiarid shrubland environments", Water Resources Research, p. , vol. , ( ). Accepted,

Mueller EN; Wainwright J; Parsons AJ, "The stability of vegetation boundaries and the propagation of desertification in the American Southwest.", Ecological Modelling, p. , vol. , ( ). Accepted,

Liu X; Monger HC; Whitford WC, "Calcium carbonate in termite galleries: biomineralization or upward transport?", Biogeochemistry, p. 241-250, vol. 82, (2007). Published,

Peters DPC; Bestelmeyer BT; Turner MG, "Cross-scale interactions and changing pattern-process relationships: consequences for system dynamics.", Ecosystems, p. , vol. , ( ). Accepted,

Peters DPC; Sala OE; Allen CD; Covich A; Brunson M., "Cascading events in linked ecological and economic systems: predicting change in an uncertain world.", Frontiers in Ecology and the Environment, p. 221-224, vol. 5, (2007). Published,

Peters, DPC; Bestelmeyer, BT; Herrick, JE; Fredrickson, EL; Monger, HC; Havstad, KM, "Disentangling complex landscapes: New insights into arid and semiarid system dynamics", BIOSCIENCE, p. 491, vol. 56, (2006). Published,

Peters DPC; Mariotto I; Havstad KM; Murray LW, "Spatial variation in remnant grasses after a grassland-to-shrubland state change: implications for restoration.", Rangeland Ecology and Management, p. 343-350, vol. 59, (2007). Published,

Reynolds JF; Stafford Smith DM; Lambin EF; Turner BL II; Mortimore M; Batterbury SPJ; Downing TE; Dowlatabadi H; Fernandez RJ; Herrick JE; Huber-Sannwald E; Jiang H; Leemans R; Lynam T; Maestre FT; Ayarza M; Walker B., "Global desertification: building a science for dryland development.", Science, p. 847-851, vol. 316, (2007). Published,

Roth GA; Whitford WG; Steinberger Y, "Jackrabbit (Lepus californicus) herbivory changes dominance in desertified Chihuahuan Desert ecosystems.", Journal of Arid Environments, p. 418-426, vol. 70, (2007). Published,

Sala, OE; Jackson, RB, "Determinants of biodiversity change: Ecological tools for building scenarios", ECOLOGY, p. 1875, vol. 87, (2006). Published,

Serna-Perez A; Monger HC; Herrick JE; Murray LW., "Carbon dioxide emissions from exhumed petrocalcic horizons.", soil science society of america journal, p. 795-805, vol. 70, (2006). Published,

Spaeth K; Peacock GL; Herrick JE; Shaver P; Dayton R., "rangeland field technques and data applications.", Journal of the Soil and Water Conservation Society, p. 114A-119A, vol. 60, (2006). Published,

Toledo DP; Abbott LB; Herrick JE, "Cover pole design for easy transport, assembly, and field use.", Journal of Wildlife Management, p. , vol. , ( ). Accepted,

Van Vuuren DP; Sala OE; Pereira HM, "The future of vascular plant diversity under four global scenarios.", Ecology and Society, p. 25, vol. 11, (2006). Published, http://www.ecologyandsociety.org/vol11/iss2/art25

White, EP; Adler, PB; Lauenroth, WK; Gill, RA; Greenberg, D; Kaufman, DM; Rassweiler, A; Rusak, JA; Smith, MD; Steinbeck, JR; Waide, RB; Yao, J, "A comparison of the species-time relationship across ecosystems and taxonomic groups", OIKOS, p. 185, vol. 112, (2006). Published,

Whitford WG; Jackson E, "Seed harvester ants (Pogonomyrex rugosa) as "pulse predators.", Journal of Arid Environments, p. 549-552, vol. 70, (2007). Published,

Yao, J; Peters, DPC; Havstad, KM; Gibbens, RP; Herrick, JE, "Multi-scale factors and long-term responses of Chihuahuan Desert grasses to drought", LANDSCAPE ECOLOGY, p. 1217, vol. 21, (2006). Published, 10.1007/s10980-006-0025-

Books or Other One-time Publications

Weems SL., "Geomorphic-banded vegetation relationships in the northern Chihuahuan Desert.", (2007). Thesis, Published
Bibliography: MS Thesis, NMSU, Las Cruces, NM

Lister D., "Small-scale erosion-driven nutrient dynamics in different vegetation communities in Jornada, New Mexico: implications for land degradation.", (2007). Thesis, Published
Bibliography: Bristol University

Duniway MC, "The functional role of petrocalcic horizons in desert ecosystems : spatial and temporal dynamics of plant water availability", (2006). Thesis, Published
Bibliography: PhD Thesis, NMSU, Las Cruces, NM

Knapp AK, Briggs JM, Childers DL, Sala OE., "Estimating aboveground net primary production in grassland and herbaceous dominated ecosystems.", (2007). book chapter, Published
Editor(s): Fahey TJ, Knapp AK
Collection: Principles and standards for measuring net primary production in long-term ecological studies.
Bibliography: Oxford University Press, Oxford, UK.

Web/Internet Site

Other Specific Products

Contributions

Contributions within Discipline:

The original resource redistribution framework for desertification that was articulated by Jornada researchers in the late 1980s has been a primary conceptual model for ecosystems research in arid and semiarid systems globally. The concept that shrub dominance in former grasslands establishes and exacerbates patchiness in soil resources and provides a positive feedback to shrub dominance has stimulated research at the Jornada and many other sites globally. More recently, our landscape linkages framework expands on the plant-interspace model to explicitly include other spatial scales by focusing on transport processes that connect patches. This framework has been successfully used to explain historic patterns that could not be explained with the simple plant-interspace model of Schlesinger et al. (1990).

The Jornada Basin has long been a key location for empirical studies of shrub invasion and desertification. The infrastructure provided by the LTER program has facilitated the Jornada's status as a premier location for desert ecology studies.

Key findings from our long-term studies illustrate the pace of response of desert organisms to environmental drivers and disturbance.

Contributions to Other Disciplines:

LTER research on desertification has promoted an understanding by soil scientists about the development and properties of arid-land soils that influence their resilience and resistance. LTER research has been particularly important in allowing geomorphologists and soil scientists to explore the feedbacks between soil properties and vegetation cover over a range of temporal and spatial scales.

Jornada research is contributing to the development of Earth system science and the understanding of phenomena linked to global environmental change. Specific examples include interactions between desertification and the generation and export of dust that feeds back to influence ecosystem processes. Recent research on inorganic carbon at the Jornada is increasing knowledge about global carbon balance.

Jornada research is actively supporting the development of remote sensing technology and analysis. Remote sensing in arid regions has traditionally been constrained by technical difficulties (e.g., predominance of the soil surface signal), but the vast expanses of relatively inaccessible arid lands with significant large-scale variation will demand improved remote sensing techniques. Ground truth data and extensive process-level studies are available at the Jornada for cross-referencing with remotely sensed imagery from aerial and satellite platforms (e.g., JORNEX). There are few such well-studied locations in semiarid and arid regions of the world, thus the Jornada will continue to make important contributions to this field.

Contributions to Human Resource Development:

The Jornada LTER and associated projects support several postdoctoral researchers, and attract visiting scientists supported by other institutions. We typically house 2-3 visiting scientists for 3-12 months each year. The program typically directs 6-12 graduate students each year working on LTER-related questions. The program also supports 2-4 REU students each summer, NMSU is a minority, Hispanic-serving institution, and we routinely include minority and female students in our REU program. In addition, Jeff Herrick is active as a mentor in the SEEDS (Strategies for Ecological Education and Development) program for the Ecological Society of America, a Mellon Foundation-supported program that recruits and supports students of color in ecology.

Contributions to Resources for Research and Education:

Jornada headquarters has a fiber optic and T-1 connectivity supported by an LTER supplement. Renovations of a historic building at the site (Turney House) provided a small meeting room and limited office space. The Jornada GIS and spatial database maintained by the JRN site office are being increasingly used by local and visiting researchers for selection and coordination of field sites. The LTER site bibliography with search/query capabilities are increasingly used by students, instructors, and researchers.

Contributions Beyond Science and Engineering:

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

Human populations and land use patterns are changing rapidly globally, and in particular in the American Southwest. Jornada research provides a basic understanding of the limits to management of livestock in these systems. Moreover, Jornada research on biodiversity, rangeland air and water quality, and other aspects of human-environment interactions are being used in regional efforts to understand and manage other human activities in arid systems beyond livestock production.

Our Schoolyard LTER program and affiliated educational programs are explicitly attempting to improve the rigor and appeal of scientific education and literacy at the K-12 level. We operate in a region of the US with largely poor, minority populations: Las Cruces school are 50-80% Hispanic with 60-90% of the students qualifying for free or reduced lunches. Thus, our program addresses scientific literacy at early stages for a diverse, under-served population.

Special Requirements

Special reporting requirements: None

Change in Objectives or Scope: None

Unobligated funds: $ 0.00

Animal, Human Subjects, Biohazards: None

Categories for which nothing is reported:

Any Web/Internet Site

Any Product

ACTIVITIES

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, our conceptual model highlighted fine-scale spatial heterogeneity of both biotic and abiotic elements of semi-arid and arid ecosystems. Our focus was on the redistribution of soil resources at the plant-interplant scale – the Jornada "teeter-totter" desertification model. In LTER IV, we embarked on a new framework aimed at a better understanding of the consequences (and 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 LTER V, we are furthering our understanding of these multi-scale processes that lead to cross-scale interactions. In particular, we are interested in the degree to which redistribution of resources (soil, nutrients, water) and propagules form the basis of linkages among spatial units across a range of scales, and explain spatial and temporal variation in patterns and dynamics across the Jornada Basin.

Synthesis activities

Conceptual framework development, team building, and a pilot study. Based on comments by the site review team in 2003, we spent a considerable amount of time prior to writing our LTER V proposal discussing: a unifying framework, collaborative research, and multi-scale experiments that would integrate all parts of our research. We met at least monthly, and often more frequently, to discuss the framework and overall hypotheses, and to develop specific testable hypotheses. We had four major PI meetings: one in Cloudcroft, NM in November (2004) and three in Las Cruces, NM in May and July (2005), and April (2007). We agreed on an overall design and hypotheses for our integrated experiment as well as teams of researchers to work on various aspects of the design. Our group became much better integrated as part of this planning process. Two major papers were published describing these ideas (Peters et al. 2004. PNAS, Peters et al. 2006. BioScience). We advertised nationally for three GRA positions that we filled by spring 2007. These students participated in the April 2007 science meeting, and are very quickly contributing to the new and exciting science being developed by our group. Our focus is the importance of connectivity and resource redistribution to landscape complexity across a range of scales, from individual plants to the entire Jornada Basin. We initiated a pilot study in 2007 to test basic assumptions about experimental design and methods to increase or decrease connectivity in resources at multiple scales. We should be in an excellent position to begin our full integrative cross-scale experiment in early 2008.

Simulation modeling. Another major integrative effort has been to combine the various simulation models. Peters, Parsons, Wainwright, and Herrick have been working to incorporate water redistribution models at fine to patch scales with ECOTONE, our vegetation dynamics model. Peters has also been working with Okin and Herrick to incorporate wind redistribution models at fine to landscape scales into ECOTONE. Fredrickson and Peters are working with an USDA ARS postdoc (Raul Peinetti) to develop an animal redistribution and energetics model to link with ECOTONE. The linked models, called ENSEMBLE, will be used to both understand historic patterns and to predict future dynamics under changing environmental conditions.

Synthesis activities and products. We have been actively engaged in synthesis activities leading to major products.

(1) We published a special issue in 2006 in the *Journal of Arid Environments* based on our new conceptual framework. A total of 10 papers were published in this issue based on Jornada research.

(2) Our LTER synthesis book was published by Oxford University Press in June 2006. This book summarizes much of the work from LTER I-III and provides an introduction to and justification for our new conceptual framework started in LTER IV.

(3) We coordinated a special issue ("Cross scale interactions and spatial heterogeneity: consequences for system dynamics") to be published in *Ecosystems* in late 2007 that extends the Jornada cross-scale framework to other sites and systems. This issue contains papers from two LTER sites (Virginia Coast Reserve [Young], Luquillo [Willig]), a paper from Australia (J. Ludwig), two fire-related papers (C. Allen, Falk), and a paper on animal metapopulations (Schooley).

(4) We are leading a special issue to be published in 2008 in *Frontiers in Ecology and the Environment* on continental-scale research that will draw heavily on LTER network-level science. This special issue will consist of the following 7 papers; each paper has at least one LTER scientist as an author:

Debra Peters, Peter Groffman, Knute Nadelhoffer, Nancy Grimm, Scott Collins, William Michener, and Michael Huston, "Living in an increasingly connected world: a framework for continental-scale environmental science" (submitted May 30, 2007)

John Marshall, John Blair, Al Rango, Mark Williams, Debra Peters, and Syndonia Bret-Harte. "Forecasting Ecosystem Responses to Climate Change and Variability at Regional-to-Continental Scales"

Todd Crowl, Bob Parmenter, and Tom Crist. "The Spread of Invasive Species and Infectious Disease as Drivers of Ecosystem Change Across Regional and Continental Gradients of Climate and Land Use"

Nancy Grimm, David Foster, Peter Groffman, Morgan Grove, Charles Hopkinson, Knute Nadelhoffer, Diane Pataki, and Deb Peters "Land Change: Ecosystem responses to urbanization and pollution"

Chuck Hopkinson Ariel Lugo, Merryl Alber. "Forecasting effects of sea level rise and catastrophic storms on coastal ecosystems"

Craig Williamson, Tim Kratz, Walter Dodds, Margaret Palmer. "Forecasting aquatic system dynamics at regional to continental-scales"

Mendy Smith and Alan Knapp. "Expanding the scale of global change experiments"

(5) We have been leading the EcoTrends Project since its inception in 2004. EcoTrends currently includes long-term data (> 10 year record) from all 26 LTER sites and an additional 24 sites supported by other agencies (USDA-FS, USDA-ARS, DOE, USGS). We plan on submitting the book, Our Changing World, to Oxford University Press in fall 2007, and will launch the more fully functional web page (http://www.ecotrends.info) at the time of publication.

(6) We are also developing a web portal (http://www.p2erls.net) to allow easy access to information about ecological research sites globally and links to their web sites. This "network of networks" (Pole to Pole Ecological Research Lattice of Sites: pronounced pearls) will promote collaborative research across a range of scales, from regions to continents and the globe.
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Specific Activities

Vegetation dynamics

Rapid Pulse Landscape Inventory of Grass Recruitment. Years of high rainfall may catalyze significant, long-term effects on the trajectory of arid ecosystems. In 2007, we initiated a new study to document the occurrence of perennial grass-dominated areas and establishment patterns of grasses and shrubs following the unprecedented rains of 2006 (in many cases 100% above average) and relatively wet spring of 2007. The landscape-wide inventory will be used to build statistical models of where recruitment did and did not occur as a function of soils, vegetation state, and landscape context. Selected plots will be used to monitor where recent recruitment events result in permanent, transient, or no change in vegetation structure. A rapid assessment of a large number of plots can be used to quantify the contributions of landscape variables to the characteristics and occurrence of vegetation states and serve as a basis for additional experiments. Long-term monitoring in selected plots will be used to test the hypothesis that establishment and community dynamics differ in distinct landscape contexts. Data collected at the plot scale will be coupled with analysis of high-resolution imagery of shrub and perennial grass patch structure. In addition, results from this pattern analysis will be used to assist in the location of future multi-scale connectivity experiments.

We are using a variety of geospatial data (landform, soils, geographic spread, road proximity) to select ca. 200 points spread across the sand sheet and transition zone geomorphic units of the Jornada where grass recruitment was observed to occur. Samples will be stratified according to soils, geomorphology, and climate heterogeneity affecting recruitment will be estimated via changes in the Normalized Difference Vegetation Index based on MODIS imagery (September 2005 vs. September 2006). This analysis will be used to identify parts of the Jornada where production was relatively high vs. low due (largely) to the distribution of rainfall. Soil, landform, and vegetation-type maps will also be used to identify strata. Plots will be 20 x 20 m and established using permanent markers. Vegetation cover and recruitment levels will be photographed and estimated using standardized ocular procedures or using line-point intercept procedures for plots selected for monitoring. Soils will be characterized to using a soil auger and field estimates (following National Cooperative Soil Survey protocols) to estimate A horizon texture, B horizon texture and carbonate accumulation, and calcic horizon development in lower B horizons. A horizon samples and samples with maximum clay accumulation will be further subjected to particle size analysis. Aerial photography gathered as part of the JORNEX project

will be classified to vegetated and non-vegetated classes in Erdas Imagine and used to extract landscape variables for each plot including bare ground connectivity, directional connectivity with respect to prevailing winds, and area of vegetation around each plot at several scales. Logistic regression and classification and trees will be used to statistically evaluate the effects of local and landscape variables on recruitment patterns and vegetation structure.

Remediation of grasslands. Large-scale degradation has resulted in widespread conversion of Chihuahuan Desert grasslands to shrublands dominated by honey mesquite (*Prosopis glandulosa*) on sandy soils. Efforts to control mesquite and re-establish native grassland vegetation have had limited success, possibly because essential water and soil resources are not retained in mesquite dune-dominated systems. Microcatchments may facilitate restoration of natural processes by reducing soil and water losses from the site. In 2003, we initiated an experiment to determine the integrated effects of vegetation manipulation treatments on mesquite control and grassland restoration at the Jornada. Treatments tested were herbicide application (Triclopyr and Clopyralid), and creation of microcatchments, followed by reseeding in June or August; the experiment was repeated in 2004 using a randomized complete block design. We continue to monitor plant cover and density annually, and soil movement every 3 months. In 2007, the vegetation manipulations produced patches with large and small interspace gaps suitable for studying aeolian sediment flux. We plan to begin aeolian sediment flux measurements in plots exhibiting different degrees of connectivity in late 2007.

Spatial variation in ANPP. In 2007, we initiated a new study at each of the 15 NPP plots representing the 5 major plant communities on the Jornada. This study was designed to address three objectives. (1) Increase our understanding of variability in spatial pattern in the long-term NPP plots. We measured the size distribution of intercanopy gaps along 4 transects in each plot. We will also analyze spatial pattern on high resolution aerial photographs using e-cognition. The information on spatial pattern will be used to compare NPP plots with the plots established in the new connectivity study. (2) To compare vegetation measurement methods as a basis for comparing trends and patterns in the NPP data with other long-term datasets based on plant cover. We measured plant cover and composition using three commonly used field-based approaches: ocular estimates of $1m^2$ quadrats, quadrat point-frames, and a line-point intercept. We will repeat these three methods using the aerial photographs. (3) To compare among ground-based measurements and between ground-based and air photo-based measurements to determine the most efficient sampling methods to address multiple objectives in desert environments.

Response of ANPP to water and nitrogen. We are continuing a study to examine the role of meristem density limitation in the response of aboveground net primary production to changes in water availability. In 2003, plots were established within a 400 ha pasture co-dominated by *Bouteloua eriopoda* and *Prosopis glandulosa.* Three 1-ha exclosures constructed in 1998 are being used to allow replication of treatments, and to avoid effects of grazing and trampling as confounding factors on plant and soil responses. We manipulate nitrogen (N) soil availability (ambient N and increased N) and incoming precipitation ranging from -80% to +80% of controls (five levels of precipitation) using a combination of passive rainout shelters and irrigation. We are using 12 replicates (4 replicates/exclosure) in the water interception and water addition treatments per nutrient level, and 18 replicates (6 reps/ exclosure) in the control treatment per nutrient level, which produces a total of 132 2.5m x 2.5m experimental units.

The rainout shelter design consists of a metal structure that supports V-shape clear acrylic bands. The bands intercept a fraction of incoming precipitation that is then routed outside the plot by a gutter. Different levels of rainfall interception are achieved by modifying the number of bands. We are using two types of shelters that intercept 50% and 80% of the precipitation. To irrigate the plots, we installed a PVC irrigation system that pumps water from a water truck to the desired plot. Rain water is collected from the Jornada headquarters roof to a fiberglass tank that is then transported to the exclosures with a water truck.

The shelters were operational starting in 2007. We will collect vegetation responses for the next two years at which time the watering and drought treatments will be reversed to examine the influence of time lags in response. In addition, minirhizotron tubes were installed in 2007 in a subset of the plots. We will begin monitoring root response (growth, biomass, and turnover) to treatments in fall 2007.

Rainout shelter that intercepts 80% of the incoming precipitation. Constructed and installed in November of 2006.

Irrigation system made of PVC piping and valves that conducts water to each plot **(a)**. The plots have two sprinklers covering 6.25 m^2 **(b)**. The irrigation system was installed during spring of 2007.

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 and May in every year possible since 2000, including 2007. We also acquired Quickbird images and purchased two Unmanned Aerial Vehicles (UAVs) to obtain 5cm resolution aerial photography. Fine-scale UAV images are being used to measure gap and patch sizes as well as percent bare soil and vegetation ground cover. One m resolution remote sensing data are being used to assess the pattern of ecological states while 15-30m resolution data are being used to delineate uniform landscape units.

Analysis of long-term data sets. We are analyzing our long-term ANPP dataset collected since 1989 to determine if predictions about the relationship between ANPP and species richness found in more mesic grasslands hold true for arid systems.

Regional vegetation and landform mapping. We are developing a landform map of the Chihuahuan Desert to provide a broad-scale understanding of desertification dynamics, and to place Jornada site results into a broader content. We are also using historic vegetation maps and climate records to examine changes in the geographic distribution of the Chihuahuan Desert boundary through time. We are collaborating with Juan Martinez-Rios (University of Durango) and Alfredo Granados-Olivas (University of Juarez) on these projects.

Animal population dynamics

Animal-animal interactions. In 2007, we initiated new studies on livestock-prairie dog interactions in an extensive area in northwestern Mexico with current flora and faunal assemblages similar to the Jornada Basin in the mid to late 1800's. We are examining: differences in breed habitat and foraging preferences, the importance of physical factors in affecting herd hierarchies and movements, and livestock – prairie dog interactions, including the possible formation of "grazing associations" that may prevent desertification by affecting prairie dog distribution and shrub establishment. We found strong seasonal associations between livestock and black-tailed prairie dogs that affect each species distribution. A successful eradication effort during the last century in New Mexico and Arizona is thought to be one factor leading to desertification in the northern Chihuahuan Desert. Our studies will elucidate mechanisms of livestock-prairie dog interactions that may have led to historic desertification patterns, and will provide information needed for the re-introduction of prairie dogs in the Southwestern US.

Transport processes, fluxes, and biogeochemistry of soil resources

Hydrologic connectivity. We developed a conceptual and numerical for emergent behavior of semi-arid vegetation based upon the concept of landscape connectivity and the role of water, wind and animals in exploiting connectivity to redistribute resources and propagules within the landscape. We also continue to collect water and sediment samples from the interrill and rill samples, stock ponds, and the North and South watershed.

Soil water dynamics in the profile. Soil profiles were characterized at each of the 15 NPP sites and soil texture data were collected in association with the NPP access tube locations. These data, together with a separate calibration study relating neutron probe counts to volumetric and plant available water, will be used to interpret long-term NPP soil water data.

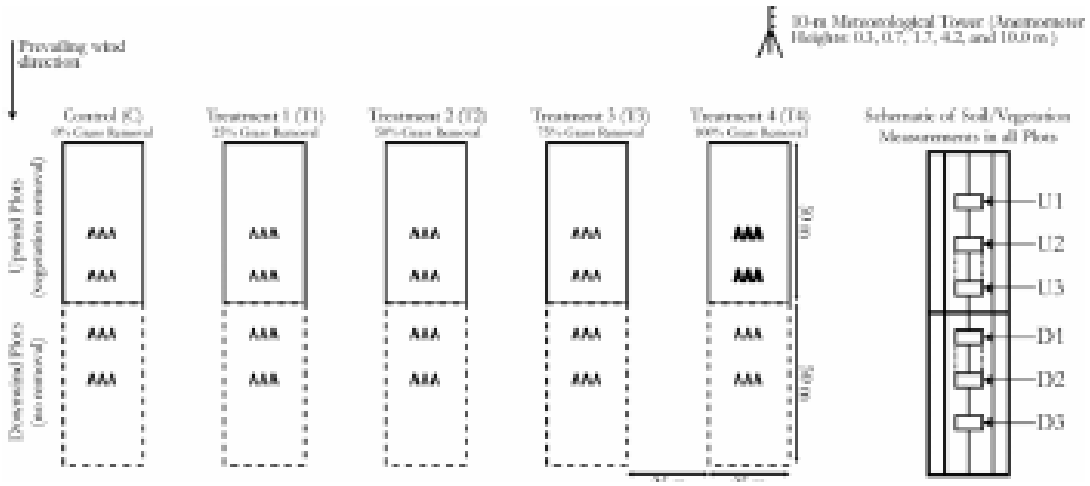
Soil carbon dynamics. We initiated a new study using carbon isotopes to compare C_4/C_3 vegetation changes in the arid vs semiarid regions of the Jornada Basin. We are also developing methods for measuring $CaCO_3$ formation/dissolution and its isotopic composition for recording relative abundances of C_3 vs C_4 plants. Through an REU student, we are assessing spatial patterns of soil organic carbon (SOC) distribution on mesquite coppice dunes. We are performing fine-scale soil sampling on dunes of different sizes to determine the influence of dune size on SOC distribution. This work will increase our ability to generate landscape-scale estimates of shrub encroachment impacts on C sequestration.

Atmospheric deposition. 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. Collections of atmospheric (wet and dry) deposition continue to be monitored seasonally. These measurements will provide (coupled with emission data) a measure of the net loss/deposition of soil nutrients by wind in the Jornada.

Wind erosion-deposition. We initiated a new landscape-wide study to determine the landforms that have experienced the least vegetation change since 1858. We will create a "resistance map" for the Jornada that can be used when stratifying future experiments. The map will also be used to interpret vegetation dynamics within the context of spatially and temporally variable drivers (wind, rainfall) compared with landforms. We also initiated an experiment to test the rate of redistribution of mesquite leaf litter by wind in landscape positions that differ in vegetation patch structure and connectivity. Data collected in 2007 are currently being analyzed.

We continue to collect data from a large-scale wind erosion experiment established at the JER in 2003. To our knowledge, this experiment is the *only* vegetation manipulation in existence 1) aimed at investigating feedbacks between aeolian processes and vegetation, 2) of a large size, and 3) in natural vegetation. The study was initially funded as an NSF award to Okin (DEB 0316320); the LTER is now assisting with plot maintenance and data collection. The wind erosion experiment consists of three blocks (replicates). Each block consists of four treatments and a control oriented perpendicular to the direction of the prevailing wind. Each treatment consists of an upwind portion where vegetation has been manipulated and a downwind portion where no vegetation manipulations have occurred. Vegetation manipulation on the upwind portion of the treatments consisted of removal of 25%, 50%, 75%, and 100% of the grasses, forbs and small shrubs such as *Gutierrezia sarothrae* in an area of 25 m x 50 m. Shrub cover (*P. glandulosa*) was low in the sites at the beginning of the experiment and was not removed. No vegetation was removed in the control. Because annuals are typically dead by the beginning of the windy season, annual cover is ignored, although each March we determine whether any

removal of annuals is necessary. Maintenance (vegetation removal) on the site was last done in March, 2007 following significant establishment in summer, 2006.



Schematic of an individual block in the wind erosion experiment. BSNE collectors are indicated by ^^^. Meteorological stations are installed in Blocks 1 and 3. The right figure shows the layout of sampling locations in each treatment. There are a total of six 5 x 10m soil sampling plots (U1, U2, U3 upwind and D1, D2, D3 downwind). There are six 50-m line-intercept transects for vegetation monitoring (3 upwind, 3 downwind). There are also 10m x 20m plots upwind and downwind where the location of every plant > 2 cm wide has been mapped.

Cross-site research

Small mammal impacts on recruitment of perennial grasses. We continue to sample vegetation responses in plots set up in 2000 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. 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 were installed in 2001, and response variables have been measured annually during peak plant growth. We are monitoring black grama basal diameters and assessing plant growth and colonization of all species within each plot. We also monitor small mammal abundance along these ecotones using mark and recapture trapping procedures. Rabbit population studies were conducted by an REU student in 2004.

Small mammal exclosure study: Field work and analysis continue 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. Annual vegetation responses were completed in 2004, although we plan on

sampling vegetation every 5 years into the future. Rodent trapping continues twice yearly as part of our animal monitoring studies.

Monitoring manual. The "Monitoring Manual for Grassland, Shrubland, and Savanna Ecosystems" published in 2005 continues to be used in training workshops held throughout the western US, Mexico, and more recently in Mongolia. This document integrates much of the LTER research and applies it to indicator selection and interpretation. A number of US agencies have adopted these methods, including the NRCS, USGS, BLM, and The Nature Conservancy.

Hydrology. In 2004-2005, we initiated hydrology studies at the Sevilleta LTER to coordinate cross-site comparisons. Fieldwork at the Sevilleta is being conducted by a graduate student who is sampling spatial characteristics of the physical and chemical properties of soils.

Network-related activities

We continue to remain active at the network level. We initiated the EcoTrends project in 2004 and continue to lead this effort (Peters, Laney, Ramsey). We participated in the LTER GIS survey and the Remote Sensing survey that resulted in articles in Databits (Nolen). We attended the annual LTER Information Managers meeting in San Jose (Nolen, Ramsey, Laney). We co-chair the Network Information Systems Advisory Committee (Peters) and have another member on this committee (Ramsey). We attended a course on "Sensing Technology for the Soil Environment" held at the Center for Embedded Networked Sensing, Riverside, CA and the workshop " Phenology Across the LTER Network" sponsored by LTER Network Office at Sevilleta, NM (Anderson). In addition, Peters was on the LTER Executive Committee until her term expired this spring.

Information Management

Activities. We continue to perform ongoing tasks of data documentation, collection, archive, and backup for all research data archived within the Jornada Information Management System (JIMS). We have been planning on how to effectively integrate GIS data layers and research site locations with research data and associated metadata to enhance the quality and availability of all JRN data and to generate more detailed and precise EML documentation. We also continue to provide GPS of research site locations and production of new GIS layers, to provide GIS and GPS support to researchers and students including training and map production, and to administer NMSU site licenses for GIS/RS software. We are populating the JIMS database with research project and associated dataset metadata to support EML generation for all Jornada Basin LTER (JRN) datasets as well as the new dynamic data catalog and data cart that will enforce the JRN data policies for download notification using a user registration system that is in beta testing. This process includes validating data structure consistency between data and metadata.

Database Server. The USDA ARS Jornada Experimental Range (JER) purchased a new database server and the JIMS' databases and Trends administrative databases have been migrated to the new server, which required upgrading from Microsoft SQL Server 2000 to 2005. During this process we discovered that Xanthoria (CAP LTER product) would not work on SQL Server 2005. This required that we develop a customized EML creation solution from metadata stored

with JIMS. New style sheets have been developed that generate EML level 3 from the JIMS database.

Integrating GIS Data, Metadata, and Services. The GIS metadata in xml will be used to generate EML documentation for all JRN GIS layers stored within JIMS, which includes geographic bounding coordinates within EML documents describing research datasets.

JRN purchased a new server to support ESRI ArcGIS Server and ArcGIS Image Server software to allow JRN researchers to query and access the JRN data, GIS layers, and imagery. We also attended the Annual ESRI International User Conference in San Diego, CA to gather technical information necessary to develop and serve the GIS services on the new GIS Server. The new GIS Server will support the following GIS Services:

- query and access to aerial photograph archive
- access research site locations (Intranet)
- online shapefile production to support research site location selection and approval
- Jornada Interactive Map (2D) on website
- Jornada Interactive Map (3D) using ArcGIS Explorer

Deployment of ESRI ArcGIS Explorer is being evaluated to support interaction with the globe services and research site locations and their associated data and metadata as well as GIS thematic layers such as vegetation, soils, and base maps.

Jornada Website. The new web server (purchased by JRN) has been installed and configured to support the new Jornada website currently in beta testing. The new website will include a new XML-based data catalog and data cart that will enforce the JRN data access policy by requiring user registration and authentication prior to download of JRN data. Users that download data will be required to supply an intended use statement upon download. Users will provide contact information, affiliation, and acknowledgement of the JRN data policies when they register with JIMS. When the beta testing of the new website is completed, the new server will be renamed and replace the web server that currently serves the Jornada website.

Education and Outreach

Education. Our schoolyard LTER program remains highly successful. In 2006-2007, we interacted with >14,000 students and > 5000 teachers from New Mexico and West Texas through in class and field activities. We also conducted teacher workshops and interacted with the public through educational outreach programs. We also maintained our strong connection with land managers throughout the western United States.

Outreach: national. Based on a synthesis of our research results together with other studies and in cooperation with the NRCS, we developed a protocol for improving ecological site and ecological site. The NRCS is now promoting the national adoption of this protocol. We also served with an interagency team (USGS, BLM and NRCS) to provide three week-long workshops to over 150 land managers on an ecological process-based rangeland assessment protocol in Colorado, Oregon and Wyoming. This protocol, much of which is supported by Jornada LTER research, is already being nationally applied by NRCS and BLM. Participants in

the 2006-2007 workshops including a number of USFS and DoD managers. We continue to publish the Jornada Trails newsletter twice a year with a mailing list of 348, and organize the Jornada Symposium, with a combined on-site and web-based audience of over 200.

Outreach: international. With support from an international supplement, we initiated the development of a network of sites in Mexico designed to examine the role of extreme events in Chihuahuan Desert dynamics. A workshop was held in Zacatecas, Mexico in April, 2005. The workshop resulted in the development of a set of standardized site characterization protocols. These protocols were subsequently applied at 18 locations distributed among 7 sites in Mexico. As part of this pilot project, over 20 Mexican scientists and students were trained in the protocols during workshops held in 2006. A database was developed that will facilitate the characterization of additional sites that can be used in the future for extreme events and other long-term research. The database was transferred to the GRACILIS network, which is part of the new Mexican LTER network and is based in San Luis Potosi.

We also hosted the Desert Project Soil-Geomorphology Tour, May 21-25, 2007. This tour brought together geomorphologists, soil scientists, ecologists, and archaeologists from 15 states, Washington DC, Nepal, Puerto Rico, and India. The tour had an attendance of 85 participants from 16 university, 5 federal agencies, and 6 consulting companies.

FINDINGS

Vegetation dynamics

Deb Peters (ARS), **Curtis Monger** (NMSU, Plant and Environmental Science), **Jeff Herrick** (ARS), and **Greg Okin** (UCLA) are using simulation models to examine effects of environmental conditions on perennial grass recruitment following shrub invasion. State changes from perennial grasslands to shrub-dominated systems characterize much of the arid regions of the world, including the American Southwest. This conversion is often difficult to reverse as a result of soil degradation and low grass seed availability. Additional recruitment processes that can limit the return of grasses are seed germination and seedling establishment, processes that are affected by both soil properties and vegetation structure. We conducted simulation model analyses to compare the probability of recruitment of the perennial grass, *Bouteloua eriopoda* (black grama), in 1858 and at present. We used a simulation model of daily soil water dynamics (SOILWAT) to simulate recruitment probabilities of black grama for the variation in conditions found at the Jornada Basin. Vegetation and landform maps combined with soils, vegetation, and weather data were used to parameterize the model. In general, simulated recruitment probabilities were higher in1858 when the Jornada was dominated by grasslands compared with the present, shrub-dominated system (Fig. 1a, b). Changes in recruitment probabilities were dependent on location-specific changes in soil properties and vegetation cover (Fig. 1c). Our results were used to identify the locations and conditions where recruitment of black grama is still possible; these areas can then be targeted for remediation efforts. We also identified the locations where remediation efforts of this grass species will fail without significant modifications to soil properties and vegetation cover. This approach to stratifying landscapes by recruitment potential can be used for other invasive species.

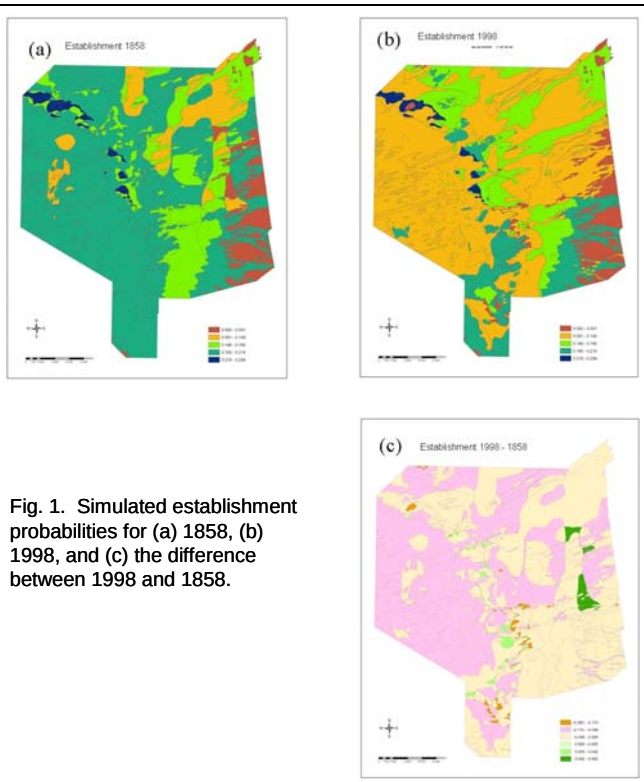


Fig. 1. Simulated establishment probabilities for (a) 1858, (b) 1998, and (c) the difference between 1998 and 1858.

We conducted additional simulations using a variable soil layer structure that occurs following either the erosion or deposition of sand during shrub encroachment. Simulated recruitment probabilities were higher where near-surface water-holding capacity (low sand content) was higher, and for sites with higher ANPP. Model results were most sensitive to the addition of 5-15 cm of sand, comparable to soil changes observed over the past 100 years (Fig. 2). Establishment probabilities decreased with the addition of 5 cm sand, and increased with the addition of 15 cm sand; largest increases were found on the most productive sites and largest decreases on the least productive sites. Removal of surface soil resulted in little change in probability of establishment.

Our results show that spatial variation in erosion-deposition patterns combined with patterns in ANPP are needed when planning restoration efforts in dynamic arid landscapes.

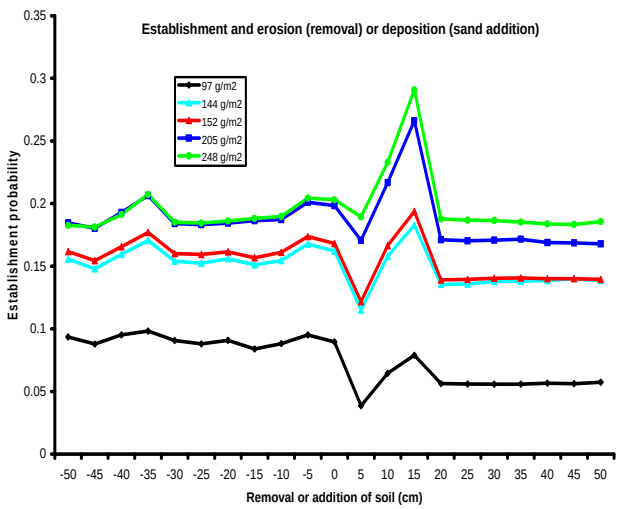


Fig. 2. Simulated establishment probability of black grama for 5 sites with different ANPP, and different amounts of sand added or removed from the soil surface.

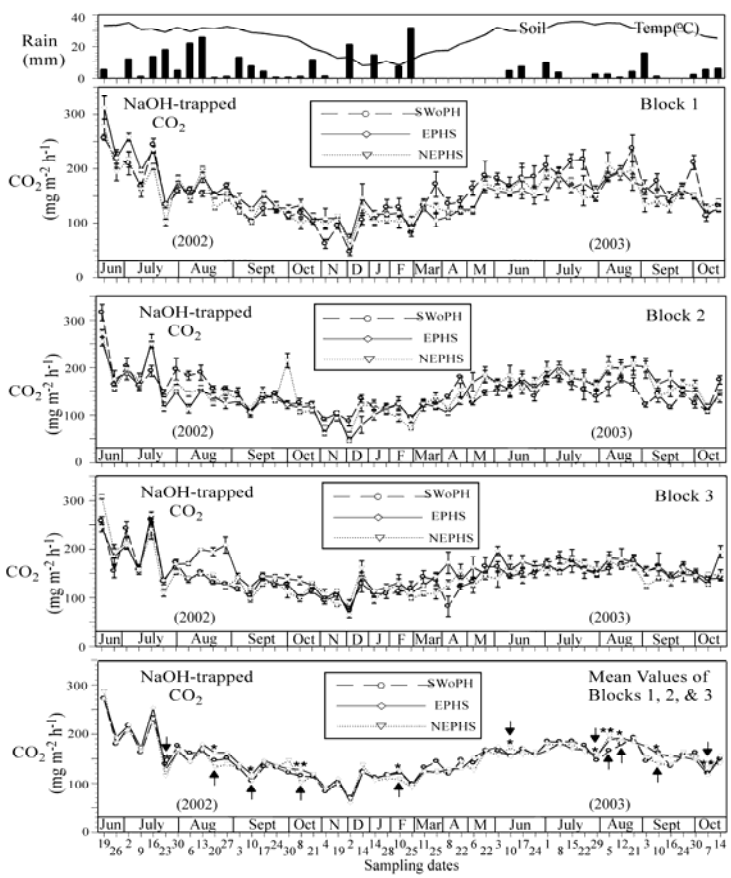
Vince Gutschick (NMSU, Biology) and his students completed a study of N dynamics in the co-dominant shrub, *Larrea tridentata.* In 2007, we completed final analyses of data obtained in 2004-2006. Tissue N contents were analyzed by combustion elemental analysis. Thirty mature plants were labeled with 15N-enriched KNO3 and then partially or wholly defoliated (or left as controls) in order to induce N remobilization. The disposition of the 15N label was traced using isotope-ratio mass spectrometry. In the complete data analyses completed in 2006-2007 we found extremely large tissue N pools, which frustrated compartmental analysis of N transfers but revealed the unexpectedly great magnitude of these pools (far exceeding pool sizes of comparable mesic plants). Coarse roots, very high in N (2%), are the largest N pool, by a considerable margin. We also found 10-fold variation in relative labeling intensities, with leaves being exceptionally responsive, and stem and root-crown wood being minimally responsive. Soil nitrate levels were measured in 2007 by flow-injection analysis. The measurements confirmed earlier reports that soluble mineral N pools are extremely high (> 100 mM as soil solution) at 1-2 m depths in these desert soils. We developed hypotheses for the role of these very high N contents, favoring the interpretation of their value as osmotica in the recurring intense water stresses and disfavoring their value in interplant competition for N for N-based defenses (apparently lacking in the species), and other aspects. A manuscript has been drafted, merging these results with 10 years of our data on leaf gas exchange plus a considerable number of studies by other researchers. The manuscript is complete except for additions to figures on stable isotopic ratios in soil and in stem wood.

Laurie Abbott (NMSU, Range Science) is studying effects of fine-scale redistribution on remediation of grasses following shrub invasion. In 2003, we initiated an experiment to determine the integrated effects of vegetation manipulation treatments on mesquite control and grassland restoration at the Jornada. Treatments tested were herbicide application (Triclopyr and Clopyralid), and creation of microcatchments, followed by reseeding in June or August; the experiment was repeated in 2004 using a randomized complete block design. Growing season (July-September) precipitation was highly variable: plots received 22%, 110%, 37%, and 310% of average growing season precipitation in 2003 – 2006. In 2006, perennial grass cover, mesquite cover and bare ground were affected by herbicide treatment ($p< 0.001$), but no effects of microcatchments or planting date were detected ($p>0.05$). Herbicide treated plots had 35% perennial grass, 2% mesquite, and 38% bare ground cover, compared to 2% perennial grass, 20%

mesquite and 70% bare ground cover on unsprayed plots. Plant establishment in 2006 indicates that the seedbank persisted through at least 2 growing seasons. Observations of perennial grass establishment under mesquite canopies and in interspaces, and lack of microcatchment effects suggest that controlling mesquite was more important than altering microsites for revegetation success.

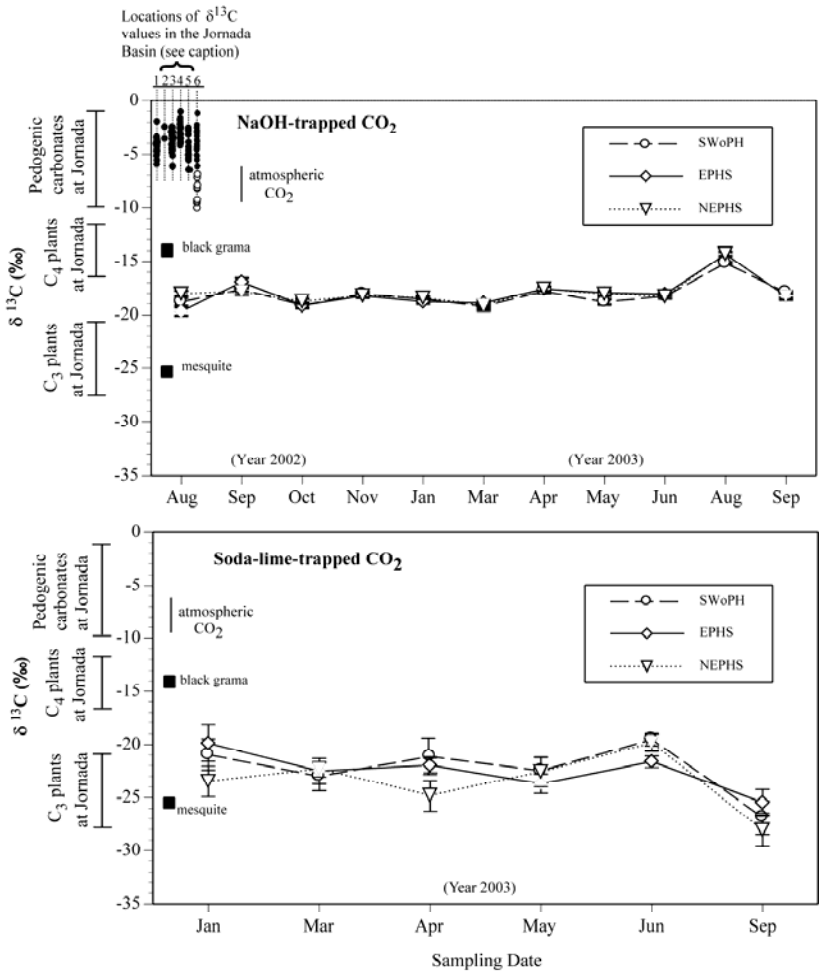
Inorganic carbon dynamics

Curtis Monger (NMSU) conducted a study of CO_2 emissions from soils with and without petrocalcic horizons. Carbon has been studied at the landscape scale by several investigators. Our researched focused on the source of CO_2—respiration versus carbonate dissolution—by testing the hypothesis that soil type 1 (eroded Aridisols with exhumed petrocalcic horizons) will emit more CO_2 than soil type 2 (non-eroded Aridisols with petrocalcic horizons) or soil type 3 (Entisols formed in sandy, noncalcareous sediments). We found no statistical difference in CO_2 emissions from the three soil types at the $\alpha = 0.05$ level. New studies will build on these results by setting up experiments that measure $CaCO_3$ development and dissolution as a function of soil depth.



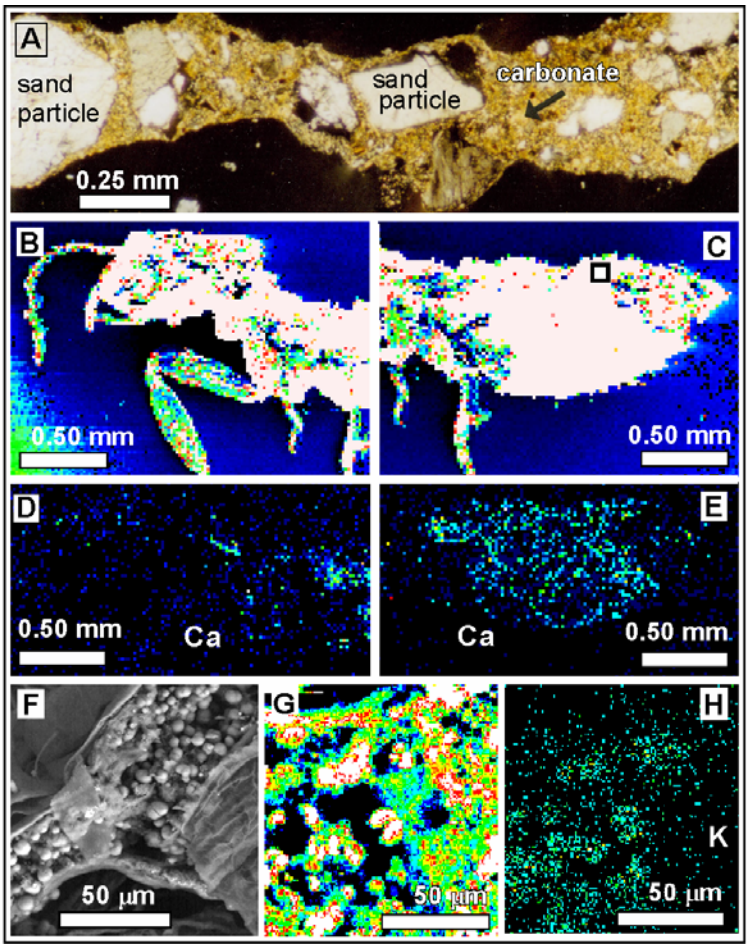
Soil CO_2 emissions for three sampling blocks across the basin floor. SWoPH=Soil without petrocalcic horizons, EPHS=Eroded petrocalcic horizon soil, NEPHS=Non-eroded petrocalcic horizon soil. Means with ** are different at $\alpha = 0.05$. Means with * are different at $\alpha = 0.20$. Arrows pointing up signify times when EPHS is higher than at least one of the other two soil types. Arrows pointing down signify times when EPHS is lower than at least one of the other two soil types. (Serna-Perez et al. 2006).

Curtis Monger (NMSU) conducted a study to identify the source of soil-respired CO_2 at the landscape scale through carbon isotopes. Using a randomized complete block design, we found that the isotopic values of soil-respired CO_2 did not match the isotopic values of pedogenic carbonate, nor were there any statistical differences ($\alpha = 0.05$) in $\delta^{13}C$ of CO_2 among the three soil types. We conclude, therefore, that exhumed petrocalcic horizons are not actively emitting CO_2 at a rate significantly greater than adjacent soils, and thus carbon stored in petrocalcic horizons can be considered a recalcitrant reservoir within the decadal timeframe. In LTER V, we will continue ^{13}C studies of soil CO_2 with the goal of increasing our knowledge about how accurately $Ca^{13}CO_3$ records the relative amounts of C_4 vs C_3 plants growing on the landscape.



Carbon isotopic values ($\delta^{13}C$) of CO_2 emissions. Each point is the mean of n = 12 (i.e., 4 reps in each plot times three plots per soil type). Range of C_4 black grama and C_3 mesquite, shown with black boxes, are from Connin et al. (1997a) and Monger (2003). Values for pedogenic carbonates shown in upper left of top figure are from the following areas in the Jornada Basin: 1. Stressor site. 2. Mayfield well. 3, 4 and 5 Liu (2002). 6. Connin et al. 1997a, b. Open circles are stage I pedogenic carbonates formed in coppice dunes. (Serna-Perez et al. 2006)

Curtis Monger (NMSU) conducted a study dealing with carbon at the landscape scale that tested the hypothesis that termites biomineralize calcium carbonate. Based on (1) field surveys, (2) $^{13}C/^{12}C$ ratios, (3) x-ray diffraction, (4) petrographic thin sections, (5) scanning electron microscopy, and (6) x-ray mapping, we concluded that carbonate in termite galleries originated from upward transport rather than biomineralization, and that this transported $CaCO_3$ plays a less active role in short-term carbon sequestration than it would have otherwise played if it had been biomineralized directly by termites. New studies will investigate biomineralization by mesquite and other plants to better understand inorganic carbon sequestration in arid and semiarid environments.

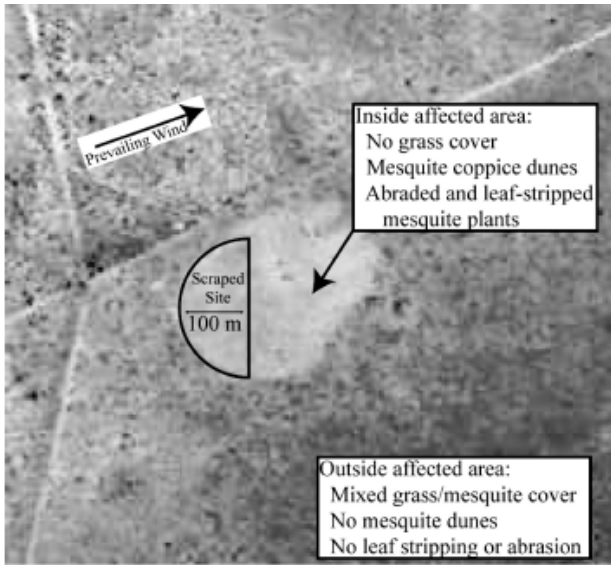


Microscopy of termite gallery and termites used to test the hypothesis that termites biomineralize calcium carbonate for gallery construction. (A) Petrographic thin section of effervescent termite gallery showing carbonate matrix. (B-C) Composite x-ray image of termite of which Ca concentration is shown below in D-E. (F) Scanning electron micrograph of crystals concentrated along the edge of termite body, located by square in C. (G) Composite x-ray image of crystals shown in SEM image to left. (H) Chemical map of image to left showing that potassium, rather than Ca, exists in greatest abundance. (Liu et al. 2007).

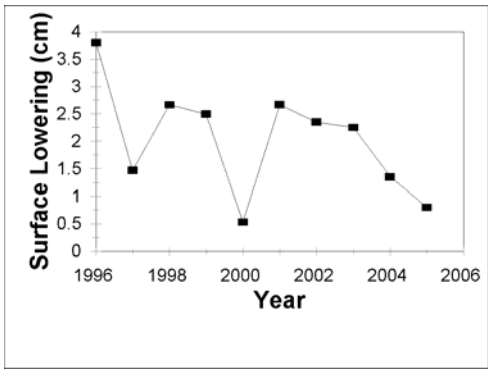
Transport processes, fluxes, and biogeochemistry of soil resources

Jeff Herrick (ARS) and **Mike Duniway** (NMSU, graduate student) characterized soil water properties of petrocalcic horizons. This study showed these materials have a plant available water holding capacity that exceeds that for many of other horizons for many of the soils in which they are found and that this water is extremely dynamic. Wetting and drying lags only slightly behind that for non-petrocalcic horizons at similar depths. This study resulted in a PhD dissertation by Duniway, and has altered the traditional view of calcic horizons as impermeable layers to dynamic layers containing plant available water.

Dale Gillette (NOAA) completed a study of dust emissions from all 15 NPP sites that was initiated in 1997. Results show that sandy soils dominated by mesquite have the highest sediment flux by wind compared to the other vegetation types. We will continue to monitor sediment flux at these sites as part of the LTER following Dale's retirement in 2007. We will also continue to monitor sediment flux from the "scrape site" – a 100 m-diameter semicircle cleared of vegetation in 1990. This site has experienced a nonlinear loss of soil through time, and is often used as a severe treatment to compare with other studies. The wind erosion experiment (See Activities) was initiated to study downwind sediment fluxes that occurred unexpectedly as a result of the complete removal of vegetation.



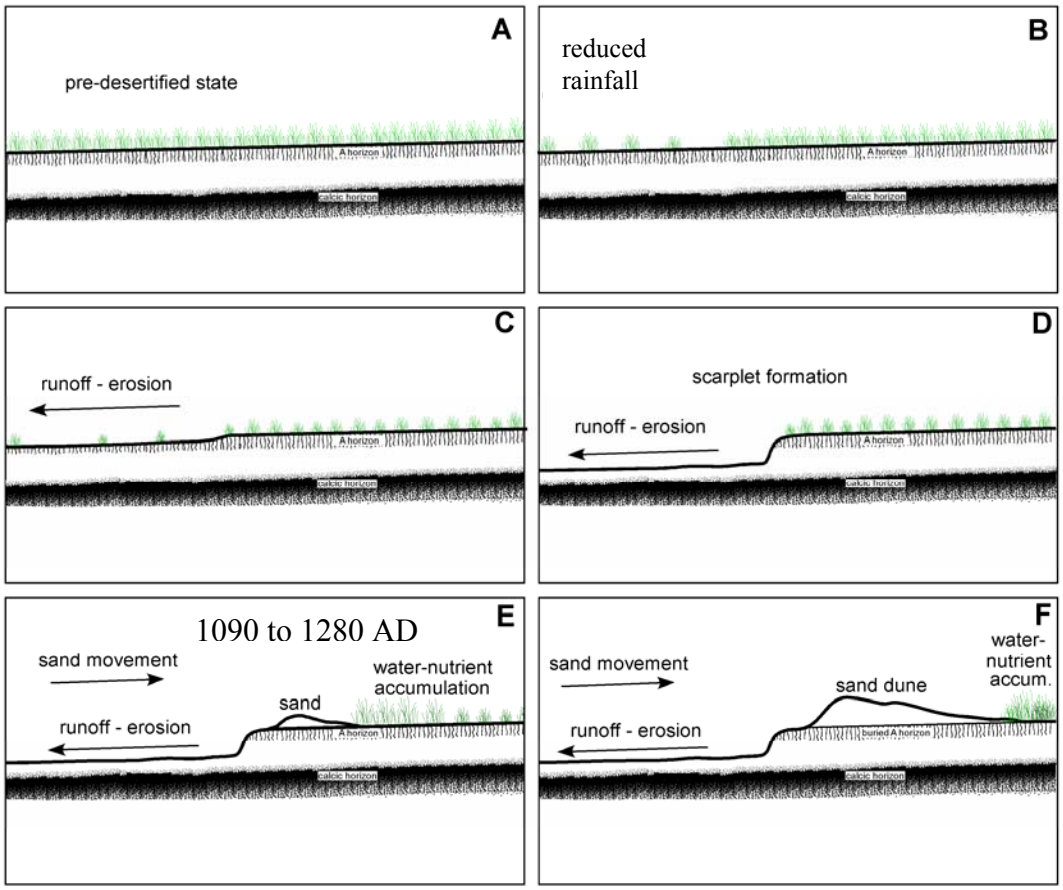
The "scraped site" in a 1999 low-altitude airborne visible/infrared spectroradiometer (AVIRIS) image with ca. 5m resolution.



Surface height at the scraped site through time.

Vegetation-soil interactions

Curtis Monger (NMSU) and **Stacey Weems** (NMSU, graduate student) conducted a study to determine the time frame and mechanisms for the formation of banded vegetation. This vegetation type has been little studied at the Jornada, yet it occurs across much of the east central part of the basin. At the Jornada, dense strips of tobosa grass that parallel sinuous sand dunes that in turn parallel erosional scarplet less than 1 meter high create banded vegetation. The erosional scarplets and the bare ground associated with them downslope are the most barren and desertified areas on the Jornada, in contrast to the dense bands of tobosa grass which have some the greatest biomass at the Jornada. We undertook a study to determine how and when these features formed. The illustration below shows the steps involved. Based on charcoal and fossil leaf dates, the sand began accumulating between 1090 and 1280 AD during the Medieval Warm Period. Results from this study will help us place the current rate of erosion into a long-term context.



Model of the formation of banded vegetation associated with erosional scarplets and linear sand dunes. Illustrations A to D depict the progressive formation of the scarplet, while E and F show the accumulation of sand that acts as an obstacle to overland flow. This creates a resource sink that leads to the dense tobosa grasslands. (Weems 2007).

Jeff Herrick (ARS) and Nicole Hansen (NMSU graduate student) conducted a study of soil erosion following encroachment by mesquite (*Prosopis glandulosa* Torr.) and other desert shrubs into the desert grasslands. Processes associated with vegetation shifts are still poorly understood. One such example of vegetation shift is the replacement of tobosa (*Pleuraphis mutica* Buckley) grasslands by mesquite dunelands on the Red Lake playa, an ephemeral lake in the northwest corner of the Jornada. The objective of this project is to define the probability of grass-shrubland transitions for vegetation patches based on soils and spatial context. We used aerial photos from 1942 and 1973 and a digital orthophoto quarter quadrangle from 1996 to define changes in the mesquite dominated area since 1942. We used the 1996 photos to compare GIS-based mesquite canopy intercept measurements with line-point intercept measurements completed in 2005. The next phase of GIS work consisted of using a 2004 QuickBird satellite image to identify current vegetation community patches based on vegetation and soil type and the spatial distribution and density of plants and bare ground within each patch. Plots were then established in the field within these patches to characterize the soils and vegetation of the site and create highly-detailed soil and vegetation maps of the site. After the initial characterization, the field data and 2004 satellite image were compared against the older imagery and past vegetation and soil maps to identify areas requiring more extensive soil and vegetation measurements. Conversion of the area from a grassland to a shrubland was likely a result of sand deposition from areas upwind.

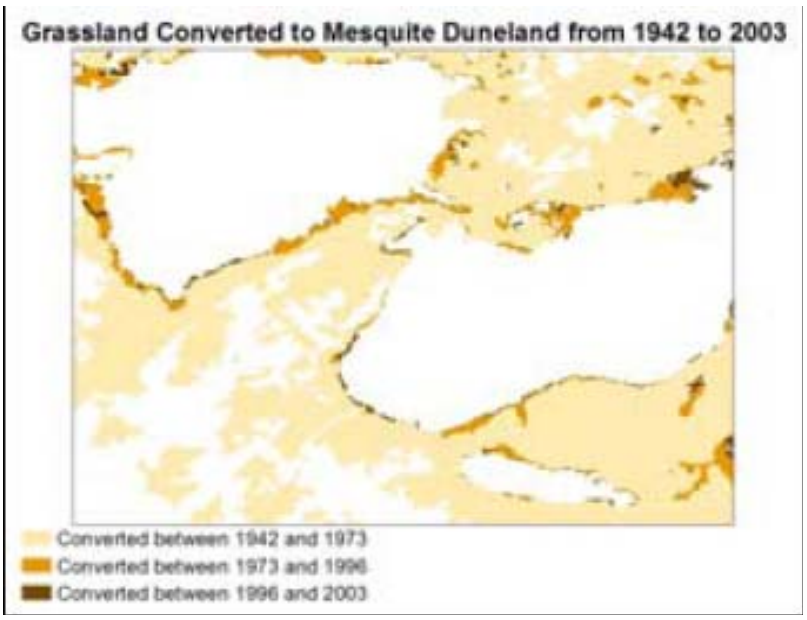


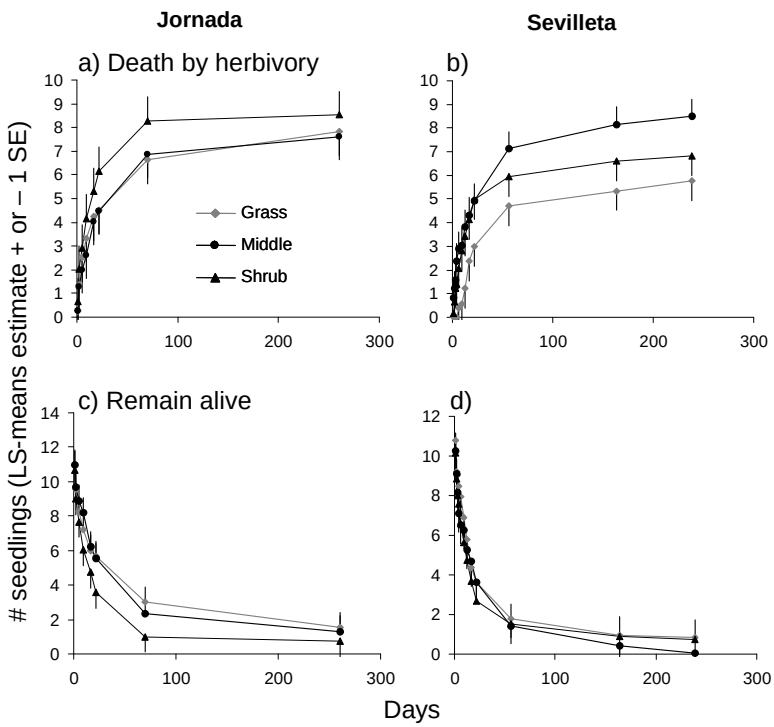
Image analysis showing change from grassland to mesquite duneland likely associated with sand deposition.

Disturbances

Jeff Herrick (ARS) completed analyses of 7 years of post-disturbance data on each of the five sites. 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. In 2007, we completed 10 year measurements. Results show that both resistance and resilience vary with both soil and disturbance type. Results also suggest that drought sensitivity may be affected by past disturbance on some soils, but not on others.

Cross-site studies

Brandon Bestelmeyer (ARS) and **Deb Peters** (ARS) conducted a study of the effects of small mammals on grass recruitment for grassland-shrubland ecotones at the Jornada and Sevilleta. Results show that seedlings were killed by small mammals in greater numbers in shrubland than in grassland or middle ecotone positions at the Jornada with large herbivore populations. At the Sevilleta low herbivore numbers, however, most seedlings were killed in middle ecotone positions. The abundance patterns of herbivores did not parallel patterns of seedling herbivory across the ecotones or between sites. We conclude that seedling herbivory is an important process and is related to vegetation composition, but the mechanisms underlying the relationship are not clear. We speculate that variation in small mammal foraging behavior may contribute to seedling herbivory patterns. We support the idea that grassland restoration strategies in the Chihuahuan Desert need to account for the abundance and/or behavior of native herbivores.



Highest seedling mortality occurred in the shrublands at the Jornada with large herbivore populations. At the Sevilleta, highest mortality occurred in the ecotone locations.