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Preview of Award 1235828 - Annual Project Report

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Cover

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|---|---|
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| PD/PI Name: | Debra P Peters, Principal Investigator Brandon Bestelmeyer, Co-Principal Investigator Stephanie V Bestelmeyer, Co-Principal Investigator Kris M Havstad, Co-Principal Investigator Hugh C Monger, Co-Principal Investigator |
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Accomplishments

* What are the major goals of the project?

Chihuahuan Desert landscapes exemplify the ecological conditions, vulnerability, and management challenges in arid and semi-arid regions around the world. The goal of the Jornada Basin Long Term Ecological Research program

(JRN LTER) established in 1982 is to understand and quantify the key factors and processes controlling ecosystem dynamics and patterns in Chihuahuan Desert landscapes. In collaboration with the Jornada Experimental Range (USDA ARS), studies initiated in 1915 have been incorporated into the JRN LTER program. Previous research focused on desertification, a state change from perennial grasslands to woody plant dominance that occurs globally. Based on findings from growing long-term databases, the breadth of studies in LTER-VI was expanded to include four additional state changes that occur in dryland systems worldwide: (1) a reversal to grassland states, (2) transitions among different states dominated by woody plants, (3) invasion by non-native grasses leading to novel states, and (4) transitions to human-dominated states. Processes of interest include water mediated plant-soil feedbacks, patch-scale contagion, landscape context, and time lags that are manifested as nonlinear dynamics and threshold behavior. The overall goal of Jornada LTER-VI (2012-2018) is to understand and quantify the mechanisms that generate alternative natural and human-dominated states in dryland ecosystems, and to predict future states and their consequences for the provisioning of ecosystem services. A modified conceptual framework and integrated research plan in LTER-VI is being used to: (1) test specific elements by coupling existing long-term studies of patterns with new experiments aimed at elucidating processes, (2) integrate data from long-term studies in novel ways to address new questions, both at the JRN and in the surrounding region, and (3) forecast alternative future landscapes and consequences for ecosystem services under a changing environment. The proposed research is organized around two major geomorphic units that characterize the Chihuahuan Desert, and that contain on-going long-term studies and a sensor network. Long-term studies are being combined with new mechanistic experiments designed to identify dominant processes and drivers with a focus on pattern-process relationships that transcend scales. The generality of this framework is being assessed with cross-site and regional studies. Simulation modeling is being used to synthesize and integrate data, both to understand current patterns and to predict future dynamics. New socio-economic studies and scenarios based on the Ecosystem Millennium Assessment are placing Jornada research into a broader socio-economic-ecologic context. Proposed research is resulting in five major products: (1) new understanding of state changes, in particular in drylands, that lead to theory development, testable hypotheses, and new experiments; (2) accessible data and visualization tools applicable at multiple scales; (3) explanatory and predictive relationships between drivers, patterns, and processes that can be used to (4) develop scenarios of alternative human- and natural-dominated states with assessments of their impacts on ecosystem services; and (5) usable information transfer to a broad audience including K-12 students and teachers, and NGO and government agency land resource managers.

The major goals of our project are:

1. To provide new understanding of state changes within geomorphic units at the Jornada
2. To compare state change transitions among different geomorphic units at the Jornada
3. To provide a more mechanistic understanding of regional dynamics within the Chihuahuan Desert
4. To provide education and outreach programs across a range of scales, from local to global
5. To enhance the accessibility of Jornada data to a broad range of users.

*** What was accomplished under these goals (you must provide information for at least one of the 4 categories below)?**

Major Activities:

GOAL 1. to provide new understanding of state changes within geomorphic units

Grassland to shrubland transitions: Little is known about how biotic interactions between grasses and shrubs influence state transition dynamics, or whether density-dependent interactions set the upper limits of shrub cover at advanced stages of encroachment. We addressed these knowledge gaps using selective removal experiments. ***Grass effects on adult shrubs.*** Growth of shrubs where grasses were removed from the area surrounding shrubs of different sizes are being analyzed to determine (i) the life history stage(s) in which shrubs respond to the loss of grasses, and (ii) if shrub growth responses to reductions in grass biomass linear or exponential. ***Adult shrub effects on grass.*** Grass growth

response to shrub abundance is being analyzed to determine the critical size/density of shrubs required to influence grass productivity. ***Shrub-shrub interactions***. To determine if density dependent interactions may set upper limits of woody cover, the growth of shrubs whose conspecific neighbors are removed are being compared with shrubs whose conspecific neighbors are left intact.

Shrubland to grassland transitions: the recent increase in native perennial grasses in some desertified shrublands suggests that climate variability may initiate state change reversals (Peters et al. 2012), long-term data show that the key recovery processes differ by grass species (Peters et al. 2013). The infrequent nature of exogenous phenomena, such as El Niño, requires long-term manipulative experiments. We are continuing a long-term experiment of rainfall manipulations (80% reduced PPT, ambient, 80% increased PPT) since 2007 to: (1) assess the effectiveness of the manipulations; (2) test hypotheses; (3) unravel the mechanisms behind hypotheses.

Shrubland to shrubland transitions: transitions between shrubland types suggest that shrub-dominated states are dynamic in the post-enchroachment phase. It is unknown if drought-avoiding mesquite will give way to creosotebush, a true xerophyte, on the sandy basin under future climatic conditions.

1. We analyzed long-term vegetation maps at different scales of resolution to determine changes in shrub species composition beginning in the 1850s.
2. We are addressing seasonal patterns of soil water use for different shrub species through the installation of a network of sapflow sensors on the east bajada. This network is in close proximity to on-going phenological sampling, a phenocam, and an eddy covariance tower. Sapflow measurements are being related to a new set of soil moisture profile observations near target plants and to an empirical method for partitioning evapotranspiration (ET) into shrub transpiration and bare soil evaporation.
3. The spatial link between ET, soil moisture, and temperature was explored through footprint analyses and a network of soil sensor profiles around the eddy covariance tower.

Transitions to novel states: The exotic grass, Lehmann's lovegrass, has not been problematic across the Chihuahuan Desert. However, higher temperatures may promote expansion of this species. We are using a soil water model (SOILWAT) to simulate establishment of lovegrass across the Southwest including the Jornada for a range of soils. We are simulating multiple climate change scenarios to examine effects of climate on the probability of recruitment.

GOAL 2: To compare state change transitions among different geomorphic units

1. Fourteen meteorological stations were recently established, one at each of the long-term Net Primary Production sites. These stations measure wind speed and direction, rainfall, air temperature, relative humidity, soil temperature and soil moisture at 3 depths, and at 5 sites albedo with short and long wavelength radiation and Phenocams for phenological characteristics . One station also measures soil carbon dioxide at 2 depths.
2. One NEON site on the basin floor and one NEON-like site on the piedmont slope continue to gather data, as do an additional flux tower and a station that is part of the Soil Climate Analysis Network (SCAN). Wind erosion is being measured at several sites across the basin floor and piedmont slopes.
3. Live-trapping grids and non-invasive camera traps were established across shrubland-grassland ecotones and in urbanized areas that continue to

determine if animal community dynamics differ among ecosystem states.

GOAL 3: To provide a more mechanistic understanding of regional dynamics within the Chihuahuan Desert.

1. We completed analyses of the relationships between biophysical variables and allotment dynamics.

GOAL 4: To provide education and outreach programs from local to global scales

We continued to leverage partnerships and non-NSF funding to support our education and outreach objectives through various activities. Specifically, we:

1. Ran a flexible science education program for K-12 students and teachers, including field trips, classroom/schoolyard science lessons, teacher workshops, and family education events based on JRN research.
2. Hosted the fourth annual Data Jam competition using the EcoTrends web site for high school and middle school students in New Mexico, shared the Data Jam model with LTER Education and Outreach coordinators, and provided materials and advice to scientists and educators at BES who subsequently hosted two Data Jams in Maryland and New York.
3. Developed cooperative agreements with numerous national and international organizations.
4. Led or co-led four 3-5 day rangeland monitoring and assessment workshops and training sessions for land management agency employees, contractors, land managers and the general public in the U.S.
5. Taught a rangeland monitoring and assessment module for mid-career professionals from developing countries for the United Nations University "Land Restoration Training" course in Iceland.
6. Continued working with land management agencies to promote adoption of a common set of rangeland monitoring protocols based in part on JRN research.
7. Continued development of the JournalMap website and worked with multiple publishers to engage their participation in the project.
8. Continued development of a Land-Potential Knowledge System with USAID support, and released two apps for soil (LandInfo) and vegetation (LandCover) data collection on the Google PlayStore, and led 6 training workshops in Kenya and Namibia, which included JRN examples of landscape structure and function.

GOAL 5: To enhance the accessibility of Jornada data to a broad range of users

1. Wooton Hall network equipment was upgraded to bring gigabit to desktop computers and replace aging equipment. The bandwidth for streaming data from the field was increased from 1.544 MB to 20 MB by using a wireless backhaul link between a local Internet service provider tower and a new, taller 100-foot tower at JER headquarters that replaced the old tower after a tree fell over a guy-wire and it collapsed. Migration of data and servers to the new storage appliance was completed.
2. Data catalog (DEIMS) data and metadata were updated and automatically uploaded to PASTA and DataOne. This required appending and converting data files from fixed to comma-separated value text format and uploading to database tables to support live exploration of research data and geodatabase population. During this process, the quality of data and associated metadata were improved and data were made more useable.

3. We began development of KLAS as a new scientific approach that takes advantage of both legacy data and new data acquired from environmental and biotic sensors, complex simulation models, and improved technologies for probing biophysical samples. This approach is a knowledge-driven, open access system that "learns" and becomes more efficient and easier to use as data streams increase in variety and size.

Specific Objectives: **GOAL 1. to provide new understanding of state changes within geomorphic units**

Grassland to shrubland transitions:

1. We are remeasuring soil and vegetation on the NEAT plot to determine how they have changed one decade after establishment.
2. The Dune Development Study will allow us to observe how plants and soils respond to increased aeolian transport. Our goal in this experiment is to kickstart the formation of a coppice dune system and to observe changes in soil, vegetation, and litter as this transition occurs. This is the type of research that can only be conducted in a longterm context.
3. Determine the strength and symmetry of plant-plant interactions at play in driving grassland-to-shrubland transitions. Specific objectives are to determine (i) the critical size/density of shrubs required to influence grass ANPP, (ii) at what life history stage shrub growth respond to the loss of grasses and if their response is linear or exponential, and (iii) if density dependent interactions may set upper limits of woody cover. These objectives are being addressed with field-based selective removal experiments along a grassland-to-shrubland continuum.

Shrubland to grassland transitions:

1. This experiment is testing three **hypotheses**. (1) Both water availability and the time that the ecosystem has been exposed to the new condition result in changes in ecosystem functioning through endogenous mechanisms. (2) The ecosystem sensitivity to reduced precipitation is different from sensitivity to increased precipitation resulting in asymmetries in the ecosystem response to chronic disturbances. (3) The interaction between cumulative endogenous with stochastic exogenous phenomena results in thresholds in population, community and ecosystem processes.

Shrubland to shrubland transitions:

1. To determine the transition patterns between shrub species at different locations across the landscape, and to determine the explanatory variables for the different transition patterns, we are overlaying spatial patterns in shrub species with different explanatory data layers, such as elevation, soil texture, geomorphology, long-term precipitation, and herbivore stocking rates.
2. To determine the extent to which individual shrub species are utilizing similar or different water sources in space and time within the geomorphic template of the Tromble weir watershed, we compared several techniques for measuring soil moisture— a network of soil profile sensors, a cosmic-ray soil moisture observing system (COSMOS) station, and water balance estimates. We found that the COSMOS estimates are adequate for capturing spatially-averaged soil moisture conditions in the basin and provide a means for making inferences about plant water uptake.

3. To study the impact of shrub-to-shrub transitions on hydrologic conditions, we are parameterizing and using a distributed ecohydrologic model that incorporates high-resolution species-level data. Alternative vegetation scenarios that depict different historical states (e.g., dominance by grass, mesquite, creosotebush, tarbush, and current vegetation) will be assessed once model confidence is built based on comparisons to instrumentation networks at the Tromble weir watershed.

Transitions to novel states:

1. To determine precipitation and temperature requirements for seedling establishment of the invasive Lehman's lovegrass on soils found throughout the Southwest.

GOAL 2: To compare state change transitions among different geomorphic units at the Jornada

1. We are measuring the degree to which the climatic drivers interact with topography and soil to explain shrubland-grassland dynamics at the ecophysiological to landscape scale.

2. Specific objectives for the animal ecology study are to (a) quantify relationships among precipitation, ANPP, consumer abundances and biomass, and predator activity, (b) determine if these relationships differ among ecological states, and (c) compare carnivore activity, herbivore abundance, and herbivory rates in relation to urbanization to evaluate top-down versus bottom-up trophic cascades.

GOAL 3: To provide a more mechanistic understanding of regional dynamics within the Chihuahuan Desert (includes BLM, LEK, future scenarios)

For the BLM analysis, we are examining relationships between ownership variables (sale transfer rates and interfamily transfers) and biophysical variables. The broad goal is to understand how social and ecological processes interact to determine the distribution of ecological states regional scale. For the MBG project, our goal is to engage directly with a community of land managers (both federal and private) to ask and answer ecological questions of interest at the regional scale using geographic information systems analysis of large, spatial datasets and monitoring data gathered by the MBG. Based on meetings with MBG we determined that the use of fire and the effects of drought are the most important concerns, so we designed a project around that interaction.

GOAL 4: To provide education and outreach programs from local to global scales

1. Increase the ability of local school districts to help students improve ecological understanding, including understanding the causes and potential impacts of climate change on local ecosystems (Schoolyard LTER program coordinated by Asombro Institute for Science Education).
2. Provide support to and collaborate with other LTER sites interested in adapting strategies developed in cooperation with JRN, including Data Jams (Asombro Institute).
3. Increase the ability of individuals and organizations to access, share, and interpret knowledge and information necessary for climate change mitigation and adaptation (Climate Data Initiative and Climate Hub).

4. Increase the number, strength and diversity of partnerships through the development and strengthening of specific cooperative agreements with national and international organizations.
5. Continue to support US land management agencies in the development, application and interpretation of rangeland monitoring and assessment protocols based on JRN science (workshops).
6. Achieve adoption of a common set of rangeland monitoring protocols based in part on JRN research.
7. Increase the number of citations that can be searched for geographically through the JournalMap website, the quality of the interface, and the number of users.
8. Initiate development of a system to provide global access to site-specific predictions of potential productivity and sustainability of natural and human-dominated ecosystems based on an understanding of soil and climate variability, and landscape connectivity.

GOAL 5: To enhance the accessibility of Jornada data to a broad range of users

The main objectives this year included:

- Infrastructure upgrades
- Complete upgrade of central storage and network equipment
- Increase bandwidth to field and expand wireless coverage to more research sites
- Web portal integration and population
- Incorporate dataset contacts, originators, and responsible investigator roles within DEIMS
- Load PASTA with Jornada research datasets, beginning with long-term datasets
- Integrate geoportal with DEIMS using ISO metadata as prototype
- Complete interface needed for PIs to update titles and abstracts for their datasets to meet LTER best practices
- Populate relational databases with research data to support Data Explorer and geodatabase
 - Convert data files to csv format for use by PASTA and data explorer
 - Upload research data (csv) to relational databases for use by data explorer (MySQL), geodatabase (SQL Server), and geoportal
- Redesign LTER website to better meet the needs of our principal investigators, post-doctoral fellows, graduate students, and staff
- Develop initial KLAS prototype

These improvements to Jornada infrastructure will improve stability, performance, and accessibility to Jornada research data by users as well as applications being developed at the Jornada and across the LTER Network.

Significant Results:

GOAL 1. to provide new understanding of state changes within geomorphic units

Grassland to shrubland transitions:

1. There was a significant decrease in soil organic carbon (SOC) and total nitrogen (TN) in the NEAT treatments compared to the control, and concentrations in the upwind treatments were less than in the downwind treatment. Compared to the initial 2004 values, upwind treatment SOC and TN concentrations have been reduced by 1/3. Values on the control plots haven't changed appreciably during this timeframe.

2. Grass ANPP responded positively to shrub removal in all years, but more so in years with above-average rainfall and in plots with high shrub abundance (Fig. 1A, B). The ANPP response of small (< 50 cm diameter) shrubs to grass removal was positive in years with above-average growing season precipitation, but this response was not evident for small shrubs in dry years or for larger shrubs (canopy diameter > 50 cm) regardless of growing season precipitation (Fig. 1C). Removal of shrub neighbors did not significantly influence target shrub ANPP relative to controls in any year (Fig. 2A) nor was there any relationship between target shrub ANPP and the abundance of conspecific shrubs within 5 m (Fig. 2B).

Shrubland to grassland transitions:

1. Results from our six-year field experiment of sequences of wet and dry years while maintaining precipitation amount constant showed that increased precipitation variability significantly reduced primary production. Dominant plant-functional types showed opposite responses: perennial-grass productivity decreased by 81% while shrub productivity increased by 67%. This pattern was explained by different non-linear responses to precipitation. Grass productivity presented a saturating response to precipitation where dry years had a larger negative effect than the positive effects of wet years. By contrast, shrubs showed an increasing response to precipitation that resulted in an increase in average productivity with increasing precipitation variability. In addition, the effects of precipitation variation increased through time.

Shrubland to shrubland transitions:

1. All three of the major shrub species were found in the 1850s throughout the eastern bajada, and the dominance patterns were developed over the past 150 years during a period of overgrazing and periodic drought. Multiple hypotheses about explanatory variables are being tested via simulation model and strategic field experiments.
2. A wet period at the Tromble weir watershed (March 2013 to October 2014) resulted in significant water losses beyond the shrub rooting zone. This recharge pulse is expected to be infrequent and lead to temporary moisture storage that will be consumed by plants in subsequent dry periods (Fig. 3a). We related eddy covariance measurements to the vegetation conditions sampled within the time-variable footprint around the tower, and developed an empirical method for partitioning ET (Fig. 3b).

GOAL 2: To compare state change transitions among different geomorphic units

1. The banded vegetation zone at the SCAN site consists of three units: a tobosa grass zone, a linear dune, and a bare zone. The tobosa grass zone developed because the linear dune is perpendicular to runoff and forms a dam that collects water. Adjacent to the linear dune on the downslope side is a zone of bare soil. Measurements of soil moisture of these three side-by-side zones reveal the dune has less soil moisture followed by the bare zone and the grass. Measurements of soil temperature show the dune has the highest temperatures followed by the grass and bare zone.
2. Abundances and biomass of desert rodents do not differ across shrub density gradients despite considerable changes in species composition. Strong annual variation in rodent abundances partly reflect lagged precipitation (previous year summer precipitation). Increased herbivory rates, herbivore abundance, and predator activity indicate bottom-up effects driven by anthropogenic resources

prevail in exurban environments.

GOAL 3: To provide a more mechanistic understanding of regional dynamics within the Chihuahuan Desert (includes BLM, LEK, future scenarios)

Our results indicate that the number of sale transfers of BLM allotments from 1937-2008 (an indicator of ranch instability and vulnerability to land-use change) was positively related to the proportion of the allotment that was covered by sandy (erodible) soil and negatively related to mean annual rainfall, distance to major cities, and distance to the US-Mexico border (Fig. 4).

GOAL 4: To provide education and outreach programs from local to global scales

1. A total of 16,427 K-12 students, 536 teachers, and 398 other adults participated in 27 field trips, 613 one-hour classroom/schoolyard lessons, 3 teacher workshops, and 8 family events, where they learned about JRN research by participating in hands-on, inquiry-based activities. Three graduate students contributed more than 35 hours to help provide background information and lead activities with students.
2. The 2015 Desert Data Jam competition was held in April 2015. In total, 102 students from southern New Mexico participated in the final competition in the high school or new middle school division. JRN staff also assisted other LTER site educators, who subsequently hosted spring 2015 Data Jam competitions in Maryland and New York.
3. Over 250 individuals representing over 20 domestic and international organizations, received training in rangeland monitoring and assessment protocols.
4. NRCS and BLM adopted and are applying a common set of rangeland monitoring protocols based in part on JRN research.
5. As of September 5, 2014, JournalMap users can use geographic, including map-based, search tools and terms to access over 18,000 articles. Usability was increased through a complete overhaul of the interface, and the number of users increased from 280 per month in August 2013 to 1763 per month in August 2014.
6. Two Land-Potential Knowledge System (Herrick et al. 2014) apps supported by cloud-based predictive models and simple analytics were successfully developed and released on the Google PlayStore. Over 150 individuals were trained.
7. Increase the number of graduate students conducting JRN related research through summer fellowship program [Josh Haussler (ASU, Sala); Adam Schreiner-McGraw (ASU, Vivoni), Owen McKenna (ASU, Sala)].
8. Two undergraduate REU students: Julie Schlichte [UTEP, B. Bestelmeyer] and Jake Stoner [ASU, Sala].

GOAL 5: To enhance the accessibility of Jornada data to a broad range of users

Infrastructure upgrades

- Completed upgrade of central storage and network equipment except for firewall
- Increased bandwidth to field wireless networks to 20 MB
- Expanded wireless coverage to 3 more towers in the field

Web portal integration

- Incorporated dataset contacts, originators, and responsible investigator roles within DEIMS
- Loaded PASTA with 59 Jornada research datasets, including all possible long-term datasets
- Integrated geoportal with DEIMS using ISO metadata as prototype virtual server
- Completed interface so that PIs can update titles and abstracts for their datasets to meet LTER best practices

Data Explorer and geodatabase population

- Started converting short term data files to csv format for use by PASTA and data explorer
- Started uploading research data (csv) to relational databases for use by data explorer (MySQL), geodatabase (SQL Server), and geoportal.
- Improve dataset classifications using the LTER controlled vocabulary to improve discovery of Jornada research data from the data catalog, data explorer, geodatabase, geoportal, LTER data portal, and DataOne

Key outcomes or
Other achievements:

GOAL 1. to provide new understanding of state changes within geomorphic units

Grassland to shrubland transitions:

1. A paper is in preparation that outlines results from the NEAT reanalysis. Two UCLA undergraduates (Dylan Oliva and Galen Coppage) participated in independent research at UCLA with Professor Okin for University credit.
2. The classic desertification paradigm emphasizes indirect abiotic feedbacks that reduce grass cover and reinforce state transition. Shrub suppression of grass ANPP was strongest at high levels of abundance, indicating that the direct biotic process of resource competition is another factor contributing to transition dynamics. Grass ANPP was also suppressed at relatively low levels of shrub abundance, suggesting that sites may be at risk for state transition earlier in the shrub encroachment process than expected.
3. In years with above-average growing season precipitation, ANPP of small shrubs was reduced when grasses were present. These results from our selective removal experiments are consistent with results from precipitation manipulation experiments. Grasses may therefore slow the rate at which shrubs attain a physical stature that can modify the physical environment in self-promoting ways. Conversely, reductions in grass cover via drought or grazing would ostensibly hasten grassland-to-shrubland transitions.
4. Intraspecific interactions between shrubs were not evident in any year, even at high levels of shrub cover/density. This suggests that as shrub encroachment progresses, maximum woody cover may be more a function of constraints on plant size than on density dependent mechanisms.

Shrubland to grassland transitions:

1. Results from the 8-year manipulations of precipitation showed grass ANPP showed a fast and substantial response while shrub ANPP had little or no response to changes in water availability. The last year was wetter than the previous 5 years however grasses that have been exposed to drought for 7 years were not able to respond to this increase in soil water suggesting that that grasses have crossed a threshold and lost their ability to respond to an increase in precipitation.

Shrubland to shrubland transitions:

1. Our view of the eastern bajada has changed from a static perception driven by today's patterns to a dynamically changing landscape based on a re-analysis of the vegetation maps at finer resolution than conducted previously. This re-analysis has led us to decide that a new, updated vegetation map is needed for the Jornada that we are planning in 2016.
2. Using our empirical relationship (Fig. 3b), we obtained the proportion of total ET linked to shrub transpiration (T). We found that T/ET was significantly related to the vegetation composition within the footprint, with higher T/ET as the amount of mesquite shrubs increased. This finding has broad implications for plant interactions within the mixed shrubland and for land-atmosphere interaction studies across many ecosystems.

GOAL 2: To compare state change transitions among different geomorphic units at the Jornada

1. Measurements of current climatic-soil relationships across the Jornada Basin LTER will improve predictions about which soils will have lower moisture and higher temperatures under different climate change scenarios. We hypothesize that changes in soil climate will have important feedbacks to vegetation and animal dynamics.
2. Temporal dynamics of desert rodents are consistent across ecological states, and desertification does not reduce overall abundances or biomass of these consumers. Urbanization creates alternative states in the American southwest in which bottom-up trophic interactions become dominant.

GOAL 3: To provide a more mechanistic understanding of regional dynamics within the Chihuahuan Desert (includes BLM, LEK, future scenarios)

The results of the BLM study will advance our understanding of how social-ecological interactions impact the trajectories of Chihuahuan Desert landscapes. The Malpai Borderlands fire study provides 1) an example in which LTER engages with a land management community based on their interests and 2) an unprecedented regional view fire distribution, effects, and interactions with climate.

GOAL 4: To provide education and outreach programs from local to global scales

1. 16,427 K-12 students with increased understanding of the Chihuahuan Desert and current research being conducted by LTER scientists.
2. More than 100 students who gained skills both interpreting and then communicating large, long-term, complex datasets to nonscientists through Data Jam competitions at their own schools.
3. Training on standard methods protocols increased the quality and consistency of rangeland monitoring and assessment data.
4. Significant cost savings were realized through the decision by NRCS and BLM to adopt a common rangeland monitoring manual developed by the Jornada instead of each agency developing its own. This also increases the future ability of the agencies to share and integrate their datasets.
5. The ability of scientists and other users to find studies based on geographic relevance was significantly increased.
6. Local awareness and understanding of how to generate and use an understanding of landscape-scale soil variability and connectivity was increased in pilot regions in Kenya and Namibia.

GOAL 5: To enhance the accessibility of Jornada data to a broad range of users

- 59 long term datasets and short term datasets have been uploaded to PASTA and DataOne from DEIMS (Jornada Basin LTER website, <http://jornada.nmsu.edu/lter>)
- Upgraded router, security appliance, and switches to extend gigabit to all desktop computers and servers in Wooton Hall
- Increased bandwidth in the field for wireless networks and streaming data collections from 1.544 to 20 MB and extended the wireless network to cover research sites near 3 more towers located at Taylor, South, West wells
- The Drupal-based JRN website was redesigned to provide a better LTER presence and better describe current JRN research focus areas. Each focus area page includes associated people, publications, data, important findings, figures, and posters. The data catalog was updated and made more useable. The Drupal content management system is supported by a relational database that allows for rapid web page development without programming. Most of the functionality of the old website has been incorporated in the new website with the addition of new features, such as the publications and datasets listings on people pages and the data catalog search interface.

*** What opportunities for training and professional development has the project provided?**

GOAL 1. to provide new understanding of state changes within geomorphic units

Grassland to shrubland transitions:

Galen Coppage: UCLA Undergraduate Student. 3 months.

Dylan Oliva: UCLA Undergraduate Student. 3 months.

Gregory Okin: UCLA faculty: 1 month.

Nate Pierce: UofA Graduate Student: 3 months

Steven Archer: UA faculty: 0.5 month

Shrubland to grassland transitions:

Jin Yao, NMSU, Staff, 1 month

Osvaldo Sala, ASU, 1 month

Laureano Gherardi, ASU, Post doc 3 months

Josh Haussler, ASU, grad student 3 months

Owen McKenna, ASU, grad student, 3 months

Shrubland to shrubland transitions:

Enrique Vivoni: Arizona State University, faculty, 1 month

Nathan Dylan Burruss, NMSU, Staff, 8 months

Adam Schreiner-McGraw, Arizona State University, graduate student, 12 months.

Federica Borio, Politecnico di Torino, visiting UA graduate students, 3 months.

Steven Archer: UA faculty: 0.5 month

Transitions to novel states:

Jin Yao, NMSU, staff, 1 month

Haitao Huang, NMSU, 1 month

GOAL 2: To compare state change transitions among different geomorphic units

Curtis Monger, NMSU, 1 month

Craig Tweedie, UTEP, 1 month

Bob Schooley, UI, 1 month

GOAL 3: To provide a more mechanistic understanding of regional dynamics within the Chihuahuan Desert (includes BLM, LEK, future scenarios)

Dr. Matthew Levi, USDA-ARS, postdoc, 6 months.

Dr. Israel del Toro, university of Copenhagen, 6 months.

GOAL 4: To provide education and outreach programs from local to global scales

Libby Grace, Asombro Institute for Science Education, staff

Stephanie Haan-Amato, Asombro Institute for Science Education, staff

Ryan Pemberton, Asombro Institute for Science Education, staff

Marianne Somerday, Asombro Institute for Science Education, staff

GOAL 5: To enhance the accessibility of Jornada data to a broad range of users

John Anderson - Technician, 12 months

Kenneth Ramsey - Technician, 12 months

James Lenz - Technician, 6 months

Valerie LaPlante - Technician, 4 months

Geovany Ramirez - postdoc, 1 month

Mitra Solgi - NMSU, grad, 12 months

Kumarpal Mandoth - NMSU, grad, 12 months

Nathan Dylan Burruss, NMSU, Staff, 4 months

*** How have the results been disseminated to communities of interest?**

GOAL 1. to provide new understanding of state changes within geomorphic units

Grassland to shrubland transitions:

Manuscripts published and in preparation that will be the main vehicle for dissemination of the results. Nathan Pierce, PhD student, completed his PhD written/oral Comprehensive Exams and made presentations at the 2015 Ecological Soc. America Annual Meeting (talk) and the 2015 LTER All Scientists Meeting (poster).

Shrubland to grassland transitions:

Two manuscripts have been published in Proceedings of the National Academy of Sciences and Ecology Letters that will be the main vehicle for dissemination of the results. In addition, results have been communicated in several forums including the Annual Meeting of the Ecological Society of America, the LTER All Scientist meeting and some international venues like the European Union meeting on arid lands in Thessaloniki, Greece.

Shrubland to shrubland transitions:

Three papers (Templeton et al., 2014; Vivoni et al., 2014; Browning et al., 2015) have been published in 2014. Two papers are in review (Schreiner-McGraw et al., 2015 in Hydrology and Earth System Sciences and Anderson and Vivoni, 2015 in Water Resources Research. Results have been presented at the American Geophysical Union (2014, 2015) and Ecological Society of America (2015).

GOAL 2: To compare state change transitions among different geomorphic units at the Jornada

Results have been disseminated to scientific communities by conference presentations and to the general public by community lectures, magazine articles, and YouTube videos.

GOAL 3: To provide a more mechanistic understanding of regional dynamics within the Chihuahuan Desert (includes BLM, LEK, future scenarios)

Two manuscripts will be published to disseminate the results, and results presented at several meetings.

GOAL 5: To enhance the accessibility of Jornada data to a broad range of users

Jornada research data and metadata are made available from multiple portals:

- LTER Data Catalog: <http://metacat.lternet.edu/das/lter/browse.jsp#JRN>
 - EcoTrends Data Portal: <http://www.ecotrends.info>
 - DataOne Data Portal: <https://cn.dataone.org/one/mercury/send/facetsQuery2?&term1=text+%3A+Jornada+&term1attribute=text&facetattribute=project&facet=Jornada%20LTER>
 - Jornada Data Catalog: <http://jornada.nmsu.edu/data-catalogs/jornada>
 - Jornada Data Explorer: <http://jornada.nmsu.edu/data-explorer-dashboard>
- DEIMS Repository: <http://github.com/lter/deims>

Jornada source code enhancements to DEIMS will be shared with the wider DEIMS and Drupal communities in the repository

DEIMS Project Page: <http://www.drupal.org/project/deims>

Jornada bug fixes and information related to DEIMS will be shared with wider DEIMS and Drupal communities within the page

ILTER All Scientist Meeting Estes Park, CO - September 2015

DEIMS Workshop (video online): <http://asm2015.ilternet.edu/working-groups/ilter-coalition-well-being-deims>

Presentation and discussion of Drupal Ecological Information Management System to LTER and iLTER community

*** What do you plan to do during the next reporting period to accomplish the goals?**

GOAL 1. to provide new understanding of state changes within geomorphic units

Grassland to shrubland transitions:

The Dune Development Study will be initiated as a simulation exercise, and field experiments quantifying: (a) grass effects on adult shrubs, (b) adult shrub effects on grasses and (c) shrub-shrub interactions along a grassland-to-shrubland gradient have recently been completed. These experiments were designed to elucidate mechanisms propelling state transitions. **Grass effects on adult shrubs.** Growth of shrubs where grasses were removed in the area surrounding shrubs of different sizes will be analyzed to determine (i) at what stage of their life cycle, shrubs respond to the loss of grasses, and (ii) are shrub growth responses to reductions in grass biomass linear or exponential. **Adult shrub effects on grass.** Data on herbaceous ANPP and diversity in grass patches with varying abundances of shrubs in their neighborhood will be analyzed to determine the critical size/density of shrubs required to influence grass ANPP. **Shrub-shrub interactions.** Data on growth of target shrubs whose conspecific neighbors have been removed across a range of shrub densities will be analyzed to determine when shrub interactions become density-dependent and set a limit on maximum shrub cover and ANPP on sites formerly dominated by grasses.

Shrubland to grassland transitions:

1. We are comparing responses during the 2004-2008 wet period with a previous wet period (1984-1988), and testing hypotheses about factors controlling similar responses. We are examining factors that led to the mortality of perennial grasses in 1989. We continue to reuse long-term data from multiple datasets and studies at the Jornada as we test additional hypotheses.
2. We will continue monitoring the two signature rainfall manipulation experiments in which we independently modify precipitation amount and variability. The first experiment in which we enhanced and decreased precipitation by 80% has been running for 9 years and has already yielded important results reflected in publications in *Oecologia*, *Ecology*, *Ecosphere* and *Functional Ecology*. The second long-term precipitation enhances interannual precipitation variability while maintaining mean annual precipitation constant. This experiment has also yielded important results published in *Proceedings of the National Academy of Sciences* and *Ecology Letters*.

Shrubland to shrubland transitions:

1. We will continue to monitor and analyze the sensor network observations from the Tromble weir watershed by quantitatively comparing: 1) different soil moisture measurement techniques at the watershed scale, 2) techniques for partitioning ET that account for individual shrub species and the spatial variability within the eddy covariance footprint, and 3) evaluating long-term simulations using the spatially-distributed approach that accounts for changes in shrub functional types.
2. We will continue to obtain imagery from unmanned aerial vehicles to quantify vegetation phenology, link these to phenological data (phenocams and sampling) and identify possible state transitions related to shrub-shrub interactions. The imagery will be processed for spatiotemporal analyses that can be used as inputs to the spatially-distributed modeling activities.
3. We will assemble the long-term data sets at the Tromble weir (now at five years of duration) to analyze trends in relation to the observed dry and wet periods in the watershed. This observational database will form the basis for developing the distributed model applications in the basin, including a model calibration and validation exercise, carried out prior to conducting the vegetation state change scenarios. These scenarios will quantify the impact of the type of vegetation in the basin on the production of runoff, evapotranspiration and recharge.

4. We will conduct vegetation surveys throughout the eastern bajada to document the historic shifts in dominant shrub species through time, and conduct a literature review to obtain species-level parameters for seed germination and seedling establishment in the SOILWAT model, and for plant competition and mortality in the Ecotone model. After the models have been verified, we will conduct simulations of historic climate and soils conditions to determine the sequence of events needed to result in today's landscapes, and then examine scenarios under future climate.

Transitions to novel states:

We plan on running the Ecotone model to examine controls on the growth and expansion of these exotic grasses at the Jornada and throughout the Southwest.

GOAL 2: To compare state change transitions among different geomorphic units at the Jornada

1. We are expanding our studies to include the Chihuahuan Desert Nature Park in the southern Jornada Basin. We will test hypotheses about how soils will respond to future change by investigating how they responded to past climate change using paleosols, erosion features, and carbon isotopes.
2. Each of the 15 CSIS sites measures wind speed at 4 heights, wind direction, and soil moisture at 10 cm. These will be instrumented as more complete met stations (air temperature, relative humidity, rainfall) this winter with 2015 supplement funds.
3. We will integrate analysis from our array of camera traps with results from the Ecotone study to determine whether spatiotemporal variation in consumer abundances not explained by bottom-up effects (precipitation and ANPP) is explained by predator activity and top-down effects.

GOAL 3: To provide a more mechanistic understanding of regional dynamics within the Chihuahuan Desert (includes BLM, LEK, future scenarios)

Publish two papers on the relationships of desert grassland fire and biophysical variables at a regional scale.

GOAL 4: To provide education and outreach programs from local to global scales

The JRN K-12 team will continue to plan and conduct field trips and classroom/schoolyard programs focused on JRN research. We will host at least one teacher workshop, four family education events, and the 2016 Desert Data Jam competition. We will continue to involve JRN graduate students in developing and implementing new K-12 programs.

GOAL 5: To enhance the accessibility of Jornada data to a broad range of users

- Web portals
- Finish converting and uploading short term datasets into PASTA and DataOne
- Improve dataset classifications using the LTER controlled vocabulary to improve discovery of Jornada research data from the data catalog, data explorer, geodatabase, geoportal, LTER data portal, and DataOne
- Streaming data
 - Evaluate MatLab Toolkit for processing streaming sensor data from data loggers in the field and climate data from NOAA data center to create LTER ClimDB harvest files
 - Continue instrumentation of climate stations and rain gauges
- Data catalog
 - Integrate maps and GIS products into data catalog and the LTER Data Portal
 - Populate Research Notification and Authorization content and forms
- Data Explorer
 - Fix permissions issue related in Data Explorer
 - Load all Jornada research data files into MySQL tables and to expose them to Data Explorer
 - Provide automated or semi-automated method for researchers to submit updated data to existing online data sets
 - Enhance query interfaces to make them more useable
- EcoNIS server
 - Document Jornada research sites to enable integration of data catalog and geoportal
 - Modify the DEIMS ISO module as needed to export metadata needed to populate the Geoportal with all Jornada research data packages
 - Develop initial map and image services for use by geoportal (discovery of services)

- Setup, integrate, package, document, and deploy EcoNIS data catalog and geoportal
- Infrastructure upgrades
- Expand central storage capacity
- Continue expansion of wireless coverage to more research sites in the field

Supporting Files

| Filename | Description | Uploaded By | Uploaded On |
|-----------------------------------|--|--------------|-------------|
| JRN_annual_report_figs_2015_1.pdf | Fig. 1. Response of grasses or shrubs to removals. | Debra Peters | 10/27/2015 |
| JRN_annual_report_figs_2015_2.pdf | Fig. 2. Response of shrubs with and without neighboring shrubs. | Debra Peters | 10/27/2015 |
| JRN_annual_report_figs_2015_3.pdf | Fig. 3. Soil moisture and soil water balance at the Tromble weir watershed. | Debra Peters | 10/27/2015 |
| JRN_annual_report_figs_2015_4.pdf | Fig. 4. Number of sale transfers of BLM allotments from 1937 to 2008 plotted against four predictor variables. | Debra Peters | 10/27/2015 |

Products

Books

Book Chapters

Bestelmeyer, BT (2015). A dryland ecologist's mid-career retrospective on LTER and the science-management interface. *Long-Term Ecological Research: Changing the Nature of Scientists* Willig, MR and Walker LR. Oxford University Press. . Status = AWAITING_PUBLICATION; Acknowledgement of Federal Support = Yes ; Peer Reviewed = Yes

Peters, DPC (2015). Tales from an LTER "lifer". *Long-Term Ecological Research: Changing the Nature of Scientists* Willig MR and Walker LR. Oxford University Press. . Status = AWAITING_PUBLICATION; Acknowledgement of Federal Support = Yes ; Peer Reviewed = Yes

Conference Papers and Presentations

Herrick, JE, Urama KC, Karl JW, Boos J, Johnson MVV., Shepherd K, Hempel J, Bestelmeyer BT, Davies J, Guerra JL, et al. (2013). *A land-potential knowledge system (LandPKS) based on local and scientific knowledge of land productivity and resilience*. 2nd Scientific Conference, United Nations Convention to Combat Desertification (UNCCD). Bonn, Germany. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Webb, N, Herrick JE, Hugenholtz C, Zobeck TM, and Okin G (2015). *A national wind erosion research network*. 18th International Soil Conservation Organization Conference. El Paso, TX, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Estiarte, M, Vicca S, Penuelas J, ... Sala OE, ... (a total of 22 authors) (2015). *ANPP-precipitation relationships in multi-year drought experiments in natural ecosystems*. Ecological Society of America annual meeting. Baltimore, MA, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Herrick, JE, Acheampong E, Beh A, Beniston JW, Karl JW, Kimiti D, and Ndungu L (2015). *Application of the global Land-Potential Knowledge System (LandPKS) mobile apps to land degradation, restoration and climate change*. The UNCCD 3rd Scientific Conference on "Combating desertification/land degradation and drought for poverty reduction

and sustainable development: the contribution of science, technology, traditional knowledge and practices". Cancun, Mexico. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Williamson, JC, Bestelmeyer BT, DiBenedetto J, and Kirt W (2015). *Applying alternative data sources to ecological site classification and description*. Society for Range Management Annual Meeting. Sacramento, CA, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Elias, E, Steele C, Rango A, and MeJia J (2013). *Assessing climate change impacts on water availability of snowmelt dominated watersheds of the Upper Rio Grande*. American Geophysical Union fall meeting. San Francisco, CA, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

McKenna, O and Sala OE (2014). *Biophysical controls over carbon and nitrogen stocks in desert playa wetlands*. American Geophysical Union Fall Meeting. San Francisco, CA, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Browning, DM, Tweedie CE, and Rango A (2013). *Bridging estimates of greenness in an arid grassland using field observations, phenocams, and time series Unmanned Aerial System (UAS) imagery*. American Geophysical Union fall meeting. San Francisco, CA, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Weltzin, J and Browning DM (2014). *Building capacity for a long-term, in-situ, national-scale phenology monitoring network: successes, challenges and lessons learned*. American Geophysical Union Fall Meeting. San Francisco, CA, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Peters, DPC, Yao J, Burruss ND, Havstad KM, Sala OE, Derner JD, Hendrickson JR, Sanderson MA, Blair JM, Collins SL, Gherardi LA, Starks PJ, and Steiner J (2015). *Can we use the past as a lens to the future? Using historic events to predict regional grassland and shrubland responses to multi-year drought or wet periods under climate change*. Ecological Society of America annual meeting. Baltimore, MA, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Monger, HC, Feng Y, and Karnjanapiboonwang A (2013). *Carbon residence times in pedogenic carbonate pools*. American Geophysical Union fall meeting. San Francisco, CA, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Yao, J and Peters DPC (2014). *Climate change in the American Southwest deserts: Opportunities for invasion by exotic grasses?*. Ecological Society of America annual meeting. Sacramento, CA, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Monger, HC (2014). *Coevolution of soil genesis and life*. 20th World Congress of Soil Science. Jeju, Korea. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Bestelmeyer, BT, Miller, JR (2015). *Collaborative adaptive landscape management (CALM) in rangelands: Discussion of general principles*. Society for Range Management Annual Meeting. Sacramento, CA, Sacramento, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Sala, OE, Gherardi LA, Haussler J, Reichmann LG, Garcia-Pichel F, and Marusenko Y (2015). *Contrasting above-ground responses to long-term precipitation and nitrogen manipulations in a desert grassland*. Ecological Society of America annual meeting. Baltimore, MA, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Gherardi, L and Sala OE (2015). *Contrasting plant-functional type responses to increased interannual precipitation variability*. Ecological Society of America annual meeting. Baltimore, MA, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Browning, DM, Duniway MC, and Tweedie CE (2014). *Cross-scale perspectives on patterns and environmental cues driving plant phenology in an arid upland grassland*. Ecological Society of America annual meeting. Sacramento, CA, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Levi, MR, Bestelmeyer BT, and Brown JR (2015). *Digital soil mapping as a tool for quantifying state-and-transition models*. Society for Range Management Annual Meeting. Sacramento, CA, USA. Status = PUBLISHED;

Acknowledgement of Federal Support = Yes

Peters, DPC, Yao J, and Sala OE (2014). *Disentangling climatic effects from biotic contingencies during extreme events: Chihuahuan desert responses to droughts and deluges*. Ecological Society of America annual meeting. Sacramento, CA, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Bagchi, S, Singh NJ, Bestelmeyer BT, and Briske DD (2015). *Distinguishing linear, nonlinear, transient and persistent vegetation dynamics to characterize empirical signatures of ecological resilience*. Ecological Society of America annual meeting. Baltimore, MA, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Smith, MD, Phillips RP, and Sala OE (2015). *Drought-Net: A global network to experimentally assess terrestrial ecosystem sensitivity to extreme drought*. Ecological Society of America annual meeting. Baltimore, MA, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Peters, DPC (2014). *Ecological challenges posed by climate uncertainty*. The Economic and Financial Risks of a Changing Climate: Insights from Leading Experts. Workshop Retreat. Washington, DC. USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Svejar, L, Bestelmeyer, BT, Peinetti, H, Adema, EO, Sosa, AA, Berterreix, GA, and Morici, EA. (2013). *Ecological site concepts for the Caldenal ecoregion*. Los Pastizales y el Hombre, producir y conservar. Santa Rosa, La Pampa, Argentina.. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

McKenna, OP, and Sala OE (2015). *Ecosystem controls over deep water percolation beneath desert playa wetlands*. Ecological Society of America annual meeting. Baltimore, MA, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Sala, OE (2014). *Ecosystem services in arid regions: paradigm change from supply to demand*. Inner Mongolia University. Inner Mongolia, China. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Gherardi, L and Sala OE (2015). *Effects of interannual precipitation variability on aboveground net primary production in global grasslands*. Long Term Ecological Research Network All Scientists Meeting. Estes Park, CO, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Bohn, T, Mascaro G, White D, and Vivoni E (2014). *Effects of land use on the predictability of land-atmosphere fluxes and moisture transport in the North American Monsoon Region*. American Geophysical Union Fall Meeting. San Francisco, CA, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Hausler, J and Sala OE (2015). *Effects of long term precipitation and nitrogen manipulation on root growth in a semi-arid grassland*. Long Term Ecological Research Network All Scientists Meeting. Estes Park, CO, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Galloza, MS, Webb NP, Zobeck TM, and Herrick JE (2015). *Evaluating soil erodibility dynamics to improve estimates of wind erosion in drylands*. 18th International Soil Conservation Organization Conference. El Paso, TX, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Burruss, ND, Peters DPC, Yao J, Havstad KM, and Scroggs SP (2015). *Explaining abrupt spatial transitions in agricultural and ecological responses to periods of extended drought in native grasslands*. Long Term Ecological Research Network All Scientists Meeting. Estes Park, CO, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Karl, JW and Gillan J (2015). *Facilitating knowledge discovery and visualization through mining contextual data from published studies: Lessons from JournalMap*. Ecological Society of America annual meeting. Baltimore, MA, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Peters, DPC, Yao J, Burruss ND, Havstad KM, Sala OE, Derner J, Hendrickson J, Sanderson M, Blair J, Collins S,

Gherardi L, Starks P, and Steiner J (2015). *Forecasting regional grassland and shrubland responses to directional changes in climate using multiyear dry or wet periods*. Long Term Ecological Research Network All Scientists Meeting. Estes Park, CO, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Corman, JR, Collins SL, Cook EM, Crenshaw CL, Dong X, Gherardi L, Grimm NB, Hale RL, Lin T, Ramos J Jr., Reichmann LG, and Sala OE (2015). *Foundations of ecosystem science: Legacy of a classic paper (Odum 1969)*. Ecological Society of America annual meeting. Baltimore, MA, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Sala, OE (2014). *Functioning of grasslands and savannas*. Columbia University. New York, NY. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Sala, OE (2014). *Functioning of grasslands and savannas*. Beijing Normal University. Beijing, China. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Sala, OE (2013). *Functioning of grasslands and savannas: productivity, water, space and time..* Open Landscapes International Conference. Hildesheim University, Germany. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Vivoni, E, Pierini N, Schreiner-McGraw A, Anderson C, Saripalli S, and Rango A (2013). *Fusing unmanned aerial vehicle imagery with high resolution hydrologic modeling*. American Geophysical Union fall meeting. San Francisco, CA, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Bestelmeyer, BT, Skaggs RK, Browning DM, Williamson JC, and Wojan CM (2015). *Geography as destiny? Social and ecological resilience in rangelands of the American southwest*. Ecological Society of America annual meeting. Baltimore, MA, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Herrick, JE, Beh A, Beniston J, Urama K, and Van der Waal C (2014). *Global crowdsourcing of soil-specific woody plant encroachment patterns and management strategies*. Ecological Society of America annual meeting. Sacramento, CA, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Moran, MS, Ponce-Campos GE, Huete A, McClaran MP, Zhang Y, Hamerlynck EP, Augustine DJ, Gunter SA, Kitchen SG, Peters DPC, Starks PJ, Hernandez M, Hottenstein JD, and Ross ML (2014). *Grassland resilience during the warm drought of the early 21st century*. Ecological Society of America annual meeting. Sacramento, CA, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Sala, OE (2014). *Grasslands and savannas under climate change*. Lanzhou University. Lanzhou, China. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Smith, JG and Throop HL (2015). *Green leaf litter alters decomposition dynamics by enhancing the quantity and quality of plant biomass in the litter pool*. Ecological Society of America annual meeting. Baltimore, MA, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Svejcar, L, Bestelmeyer BT, and James D (2015). *Herbivore effects on grassland recovery potential in the Chihuahuan desert*. Society for Range Management Annual Meeting. Sacramento, CA, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Karl, JW, McCord SE, Kachergis E, and Herrick JE (2015). *Implementing AIM-based monitoring for natural resource management*. Society for Range Management Annual Meeting. Sacramento, CA, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Toledo, D, Sanderson MA, Goslee S, and Herrick JE (2015). *Integrating rangeland and pastureland assessment methods into a national grazingland assessment approach*. Society for Range Management Annual Meeting. Sacramento, CA, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Karl, JW, Herrick JE, Gillan J (2015). *JournalMap: discovering location-relevant knowledge from published studies for sustainable land use, preventing degradation, and restoring landscapes*. The UNCCD 3rd Scientific Conference on

"Combating desertification/land degradation and drought for poverty reduction and sustainable development: the contribution of science, technology, traditional knowledge and practices". Cancun, Mexico. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Karl, JW (2013). *JournalMap: research reimagined*. International Association of Scientific, Technical and Medical Publishers 2013 Innovations Seminar. London, UK. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Ramirez, G and Peters DPC (2015). *Knowledge, learning, analysis system*. Long Term Ecological Research Network All Scientists Meeting. Estes Park, CO, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Sala, OE, Gherardi LA, Reichmann LG, and Peters DPC (2014). *Lags in the response of ecosystems to directional changes in water availability*. Ecological Society of America annual meeting. Sacramento, CA, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Cosentino, BJ, Schooley RL, Bestelmeyer BT, McCarthy AJ, and Sierzega K (2014). *Landscape restoration supports genetic connectivity among populations of a keystone species*. Ecological Society of America annual meeting. Sacramento, CA, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Vivoni, ER (2014). *Las interacciones atmósfera-tierra durante el monzón de América del Norte: estudios ecohidrológicos de modelación y de campo*. Reunión Anual Union Geofísica Mexicana. Puerto Vallarta, Jalisco, Mexico. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Cosentino, BJ, Schooley RL, Bestelmeyer BT, and Coffman JM (2014). *Local and landscape-scale constraints on the response of a keystone rodent to habitat restoration*. 11th International Mammalogical Congress. Belfast, Northern Ireland.. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Pierce, N, Archer SR, Bestelmeyer BT (2015). *Location, location, location: The influence of plant neighborhood configuration on grass-shrub interactions*. Ecological Society of America annual meeting. Baltimore, MA, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Goodrich, D, Kustas W, Cosh M, Moran S, Marks D, Jackson T, Bosch D, Rango A, Seyfried M, Scott R, Prueger J, Starks P, and Walbridge M (2014). *Long-term network experiments and interdisciplinary campaigns conducted by the USDA-Agricultural Research Service*. American Geophysical Union Fall Meeting. San Francisco, CA, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Biederman, J, Scott R, Bowling D, Litvak M, Oechel W, Kolb T, Goulden M, Blanken P, Yezpe E, Watts C, Vivoni ER, Rodriguez J, Garatuza J, Dore S, Bell T, and Burns S. (2014). *Maturing flux datasets reveal carbon uptake sensitivity to temporal climate variability across a summer-rainfall gradient*. AmeriFlux Annual Meeting. Potomac, MD. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

DeMarco, J, and Throop HL (2015). *Microsite location and litter quality influence shrub and grass litter decomposition in two drylands in the southwestern United States*. Ecological Society of America annual meeting. Baltimore, MA, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

McCord, SE, Kachergis EJ, James D, Karl JW, and Wilson D (2014). *Multi-scale ecosystem monitoring: an application of scaling data to answer multiple ecological questions*. Ecological Society of America annual meeting. Sacramento, CA, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Maynard, JJ, Karl JW, and Browning DM (2014). *Near real-time detection of drought severity using MODIS time series: implication for a national monitoring program*. 16th William T. Pecora Memorial Symposium: Global Priorities in Land Remote Sensing. Denver, CO, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Bestelmeyer, BT (2015). *Operationalizing resilience using state and transition models*. 68th World Congress on Ecological Restoration. Manchester, UK. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Browning, DM, Mattocks M, and Tweedie C (2015). *Phenocams as a proxy for primary productivity and mode of*

discovery in arid grassland ecosystems. Society for Range Management Annual Meeting. Sacramento, CA, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Browning, DM and Tweedie C (2014). *Phenocams as a proxy for primary productivity and mode of discovery in an arid grassland*. 7th Annual Phenology Research and Observations of Southwest Ecosystems Symposium. Tucson, AZ, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

McKenna, OP, and Sala OE (2015). *Playa wetlands as hot spots of desert nutrient storage and ANPP*. Long Term Ecological Research Network All Scientists Meeting. Estes Park, CO, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Rango, A, Elias E, Steele C, Mejia J, and Fernald A (2013). *Potential impacts of climate warming on runoff from snowmelt: a case study of two mountainous basins in the Upper Rio Grande*. American Geophysical Union fall meeting. San Francisco, CA, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Yao, J. and Peters DPC (2015). *Projected future distribution of an invasive grass, Lehmann lovegrass, in the Chihuahuan Desert*. Long Term Ecological Research Network All Scientists Meeting. Estes Park, CO, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Karl, JW and Gillan J (2015). *Protocols for vegetation and habitat monitoring with unmanned aerial vehicles: Linking research to management on US public lands*. Ecological Society of America annual meeting. Baltimore, MA, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Maxwell, CJ, Rango A, and Browning DM (2015). *Regulations and considerations for operating unmanned aircraft systems in the United States: The good, the bad, and the ugly*. Ecological Society of America annual meeting. Baltimore, MA, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Schmugge, T, Elias EH, Rodell M, and Rango A (2014). *Satellite observations of ground water changes in New Mexico*. 59th Annual New Mexico Water Conference. Santa FE, NM, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Browning, DM, Maynard J, Karl J, and Peters DPC (2014). *Seasonal shifts in satellite time series portend vegetation state change – verification using long-term data in an arid grassland ecosystem*. American Geophysical Union Fall Meeting. San Francisco, CA, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Schreiner-McGraw, AP, Vivoni E, Browning DM (2015). *Shrub strategies in a competition for water determine ecosystem state*. Ecological Society of America annual meeting. Baltimore, MA, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Yao, J and Peters, DPC (2015). *Simulated distribution of an invasive grass, Lehmann lovegrass, in the Chihuahuan Desert under future climate scenarios*. Ecological Society of America annual meeting. Baltimore, MA, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Sala, OE (2013). *Social, ecological and economic drivers of abrupt grass-woodland transitions: scales and interactions*. Stockholm Resilience Centre. Royal Swedish Academy of Sciences, Sweden. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Bestelmeyer, BT (2015). *Spatial scaling concepts as applied to the assessment and restoration of drylands*. US-International Association for Landscape Ecology. Portland, OR, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Bestelmeyer, BT, Brown JR, Densambuu B, Havstad KM, Herrick JE, and Peinetti HR (2013). *State-and-transition models as guides for adaptive management: What are the needs?*. Los Pastizales y el Hombre. Santa Rosa, La Pampa, Argentina.. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Ochoa, C, Guldan S, Fernald A, Tidwell V, Elias E, Gutierrez K, and Borman M. (2014). *Surface water and shallow groundwater interactions in semiarid agro-ecosystems of western USA*.. EGU General Assembly. Vienna, Austria.

Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Vivoni, ER (2014). *Terrain-vegetation-atmosphere interactions during the North American monsoon*. American Geophysical Union Fall Meeting. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Peters, DPC, Bestelmeyer BT, Bestelmeyer SV, Havstad KM, Monger C, Okin GS, Sala OE, Vivoni ER, Archer SR, Duniway MC, Herrick JE, Rango A, Sayre NF, Schooley RL, Throop HL, Tweedie CE (2015). *The Jornada Basin Long Term Ecological Research Program*. Long Term Ecological Research Network All Scientists Meeting. Estes Park, CO, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Steele, C, Smith A, and Browning DM (2014). *The NDVI: back to basics*. American Geophysical Union Fall Meeting. San Francisco, CA, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Burruss, ND, Peters DPC, Yao J, Havstad KM, and Scroggs SP (2015). *The ecology of catastrophic events: Understanding abrupt spatial transitions in susceptibility of grasslands and croplands to multi-year drought*. Ecological Society of America annual meeting. Baltimore, MA, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

DaVanon, KA, Howard L, Bestelmeyer BT, Mabry KE, and Schooley RL (2014). *The effects of urbanization on state change mediated by predator-prey interactions*. Ecological Society of America annual meeting. Sacramento, CA, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

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Previtali, MA, Milstead WB, Meserve PL, Mathenia M, Kelt DA, Campanella A, and Gutierrez JR (2014). *The influence of rainfall on small mammal demography: Differences among species and habitats of semiarid Chile*. Ecological Society of America annual meeting. Sacramento, CA, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Beniston, JW, Herrick JE, Beh A, Urama K, Shepherd K, and Karl JW (2014). *The land potential knowledge systems: utilizing crowdsourced data and cloud-based analytics to predict soil productivity and degradation risk*. Soil Science Society of America Annual Meeting. Long Beach, CA, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Chappell, A, Webb N, Butler H, Strong CL, McTainish G, Lleys J, and Rossel RV (2013). *The role of carbon dust emission as a global source of atmospheric CO₂*. Soil Carbon Sequestration for Climate, Food Security and Ecosystem Services International Conference. Reykjavik, Iceland. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

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Ratajczak, Z, Collins SL, D'Odorico P, Nippert JB, Isbell F, and Bestelmeyer BT (2015). *The temporal dimension of regime shifts: How long can ecosystems operate beyond critical thresholds before transitions become irreversible?*. Ecological Society of America annual meeting. Baltimore, MA, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Monger, HC, Anjos LHC, Zhang G, Goryachkin SV, Harms B, Schad P, Fox C, Sonn Yeon-kyu G (2014). *Toward a global system of soil horizon nomenclature*. 20th World Congress of Soil Science. Jeju, Korea. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

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Rango, A, Elias E, Steele C, and Havstad K (2014). *USDA Southwest Regional Hub for adaptation to and mitigation of climate change*. American Geophysical Union Fall Meeting. San Francisco, CA, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Browning, DM, Maynard JJ, Karl JW, and Peters DPC (2015). *Unraveling the mystery of dryland plant phenology through time and space with multi-scale remote sensing*. Ecological Society of America annual meeting. Baltimore, MA, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Gillan, J and Karl JW (2014). *Using JournalMap to improve ecological knowledge discovery and visualization*. Ecological Society of America annual meeting. Sacramento, CA, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Herrick, JE (2015). *Using soils and land potential as a basis for land use decisions and conservation planning: a resilience-based strategy*. Ecological Society of America annual meeting. Baltimore, MA, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Rango, A, Browning DM, Vivoni E, Anderson CA, and Laliberte A (2013). *Utilization of unmanned aerial vehicles for rangeland resources monitoring in a changing regulatory environment*. American Geophysical Union fall meeting. San Francisco, CA, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

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Sala, OE (2013). *Woody-plant encroachment: degradation or a shift in the portfolio of ecosystem services?*. National Academies Keck Future Initiative. Chicago, IL.. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Inventions

Journals

Anadón, JD, Sala OE, and Maestre FT. (2014). Climate change will increase savannas at the expense of forests and treeless vegetation in tropical and subtropical Americas. *Journal of Ecology*. 102 1363. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1111/1365-2745.12325

Archer, SR, Predick, KI (2014). An ecosystem services perspective on brush management: research priorities for competing land use objectives. *Journal of Ecology*. 102 1394. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 1111/1365-2745.12314

Barnes, PW, Throop HL, Archer SR, Breshears DD, McCulley RL, and Tobler MA (2015). Sunlight and soil-litter mixing: Drivers of litter decomposition in drylands. *Progress in Botany*. 76 273. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1007/978-3-319-08807-5_11

Bestelmeyer, BT (2015). National assessment and critiques of state-and-transition models: the baby with the bathwater. *Rangelands*. 37 125. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Bestelmeyer, BT, Okin GS, Duniway MC, Archer SR, Sayre NF, Williamson JC, and Herrick JE (2015). Desertification, land use, and the transformation of global drylands. *Frontiers in Ecology and the Environment*. 13 28. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1890/140162

Bestelmeyer, SV, Elser MM, Spellman KV, Sparrow EB, Haan-Amato SS, and Keener A (2015). Collaboration, interdisciplinary thinking, and communication: new approaches to K–12 ecology education. *Frontiers in Ecology and the Environment*. 13 37. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

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Knapp, AK, Hoover DL, Wilcox KR, Avolio ML, Koerner SE, La Pierre KJ, Loik ME, Luo Y, Sala OE, and Smith MD (2015). Characterizing differences in precipitation regimes of extreme wet and dry years: implications for climate change experiments. *Global Change Biology*. 21 2624. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1111/gcb.12888

Lorenz, RD, Neakrase LD, and Anderson JD (2015). In-situ measurement of dust devil activity at La Jornada Experimental Range, New Mexico, USA. *Aeolian Research*. . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1016/j.aeolia.2015.01.012

Monger, C, Sala OE, Duniway MC, Goldfus H, Meir IA, Poch RM, Throop HL, and Vivoni ER (2015). Legacy effects in linked ecological–soil– geomorphic systems of drylands. *Frontiers in Ecology and the Environment*. 13 13. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Okin, GS, Moreno-de las Heras M, Saco PM, Throop HL, Vivoni ER, Parsons AJ, Wainwright J, and Peters DPC (2015). Connectivity in dryland landscapes: shifting concepts of spatial interactions. *Frontiers in Ecology and the Environment*. 13 20. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Peters, DPC, Havstad KM, Archer SR, and Sala OE (2015). Beyond desertification: new paradigms for dryland landscapes. *Frontiers in Ecology and the Environment*. 13 4. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Rachal, DM, Okin GS, Alexander C, Herrick JE, and Peters DPC (2015). Modifying landscape connectivity by reducing wind driven sediment redistribution, Northern Chihuahuan Desert, USA.. *Aeolian Research*. 17 129. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1016/j.aeolia.2015.03.003

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Scheffer, M, Bascompte J, Bjordam TK, Carpenter SR, Clarke LB, Folke C, Marquet P, Mazzeo N, Meerhoff M, Sala

OE, and Westley FR (2015). Dual thinking for scientists. *Ecology and Society*. 20 1. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Svejcar, LN, Bestelmeyer BT, Duniway MC, and James DK (2015). Scale-dependent feedbacks between patch size and plant reproduction in desert grassland. *Ecosystems*. 18 146. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1007/s10021-014-9818-9

Toledo, D, Sanderson M, Herrick JE and Goslee S (2014). An integrated approach to grazingland ecological assessments and management interpretations.. *Journal of Soil and Water Conservation*. 69 110A. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.2489/jswc.69.4.110A

Vandegehuchte, ML, Sylvain ZA, Reichmann LG, Milano de Tomasel C, Nielsen UN, Wall DH, and Sala OE (2015). Responses of a desert nematode community to changes in water availability. *Ecosphere*. 6 article 44. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1890/ES14-00319.1

Vivoni, ER, Rango A, Anderson CA, Pierini NP, Schreiner-McGraw A, Saripalli S. and Laliberte AS (2014). Ecohydrology with unmanned aerial vehicles. *Ecosphere*. 5 article 130. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1890/ES14-00217.1

Yahdjian, L, Sala OE, and Havstad KM (2015). Rangeland ecosystem services: shifting focus from supply to reconciling supply and demand. *Frontiers in Ecology and the Environment*. 13 44. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1890/140156

Licenses

Other Products

Other Publications

Peters, DPC (2015). *Ecological challenges posed by climate uncertainty*. In "The Economic and Financial Risks of a Changing Climate: Insights from Leading Experts Workshop Report, Resources for the Future, Washington, DC. USA.". Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Herrick, JE, Arnalds O, Bestelmeyer BT, Brigneu S, Han G, Johnson MV, Lu Y, Montanarella L, Pengue W, and Toth G (2015). *Land potential evaluation: a strategy for sustainable land use planning and management*. United Nations Environment Program report. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Chambers, J, Deswood H, Elias EH, Havstad KM, Kerr A, Rango A, Schwartz M, Steenwerth KL, Steele C, Stine P, and 10 other authors (2015). *Southwest Regional Climate Hub and California Subsidiary Hub assessment of climate change vulnerability and adaptation and mitigation strategies*. Government Report. Anderson, T, ed., United States Department of Agriculture, 76 pp.. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Patents

Technologies or Techniques

Thesis/Dissertations

Smith, JG. *An exploration of the influence of animals on soil organic carbon dynamics in dryland ecosystems*. (2014). New Mexico State University. Acknowledgement of Federal Support = Yes

Anderson, CA. *Assessing land-atmosphere interactions through distributed footprint sampling at two eddy covariance towers in semiarid ecosystems of the Southwestern U.S.*. (2013). Arizona State University.. Acknowledgement of Federal Support = Yes

Hewins, DB. *Exploring the role of soil-litter mixing on decomposition in dryland ecosystems*. (2013). New Mexico State University. Acknowledgement of Federal Support = Yes

Davanon, KA. *The effects of urbanization on mammalian predator-prey dynamics in Las Cruces, New Mexico*. (2015). New Mexico State University. Acknowledgement of Federal Support = Yes

Websites

Participants/Organizations

Research Experience for Undergraduates (REU) funding

Form of REU funding support: REU supplement

How many REU applications were received during this reporting period? 4

How many REU applicants were selected and agreed to participate during this reporting period? 2

REU Comments:

What individuals have worked on the project?

| Name | Most Senior Project Role | Nearest Person Month Worked |
|------------------------|--------------------------|-----------------------------|
| Peters, Debra | PD/PI | 2 |
| Bestelmeyer, Brandon | Co PD/PI | 1 |
| Bestelmeyer, Stephanie | Co PD/PI | 4 |
| Havstad, Kris | Co PD/PI | 1 |
| Monger, Hugh | Co PD/PI | 3 |
| Archer, Steve | Co-Investigator | 1 |
| Duniway, Michael | Co-Investigator | 1 |
| Herrick, Jeffrey | Co-Investigator | 1 |
| Okin, Gregory | Co-Investigator | 1 |
| Rango, Albert | Co-Investigator | 1 |
| Sala, Osvaldo | Co-Investigator | 1 |
| Sayre, Nathan | Co-Investigator | 1 |
| Schooley, Robert | Co-Investigator | 1 |
| Throop, Heather | Co-Investigator | 1 |
| Tweedie, Craig | Co-Investigator | 1 |

| | | |
|-----------------------|---|----|
| Vivoni, Enrique | Co-Investigator | 1 |
| del Toro, Israel | Postdoctoral (scholar, fellow or other postdoctoral position) | 3 |
| Gherardi, Laureano | Postdoctoral (scholar, fellow or other postdoctoral position) | 3 |
| Levi, Matthew | Postdoctoral (scholar, fellow or other postdoctoral position) | 6 |
| Ramirez, Geovany | Postdoctoral (scholar, fellow or other postdoctoral position) | 3 |
| Brown, Joel | Other Professional | 1 |
| Browning, Dawn | Other Professional | 1 |
| Buenemann, Michaela | Other Professional | 1 |
| Burruss, Nathan | Other Professional | 6 |
| Grace, Libby | Other Professional | 3 |
| Haan-Amato, Stephanie | Other Professional | 4 |
| Mabry, Karen | Other Professional | 1 |
| Pemberton, Ryan | Other Professional | 3 |
| Somerday, Marianne | Other Professional | 3 |
| Anderson, John | Technician | 12 |
| Chepsongol, Roxanne | Technician | 12 |
| Feng, Yanhua | Technician | 12 |
| Gamboa, Bernice | Technician | 1 |
| Gename, Kyle | Technician | 12 |
| Hall, Seth | Technician | 12 |
| Harrison, Charlene | Technician | 6 |
| LaPlante, Valerie | Technician | 4 |

| | | |
|---------------------------|---|----|
| Lenz, James | Technician | 4 |
| Ramirez, Gesuri | Technician | 6 |
| Ramsey, Kenneth | Technician | 12 |
| Schrader, Theodore | Technician | 6 |
| Yao, Jin | Staff Scientist (doctoral level) | 6 |
| Campos, Herman | Graduate Student (research assistant) | 3 |
| DaVanon, Kristen | Graduate Student (research assistant) | 3 |
| Haussler, Josh | Graduate Student (research assistant) | 3 |
| McKenna, Owen | Graduate Student (research assistant) | 3 |
| Ortiz, Anna | Graduate Student (research assistant) | 3 |
| Pierce, Nate | Graduate Student (research assistant) | 3 |
| Schreiner-McGraw, Adam | Graduate Student (research assistant) | 12 |
| Solgi, Mitra | Graduate Student (research assistant) | 2 |
| Schlichte, Julie | Research Experience for Undergraduates (REU) Participant | 3 |
| Stoner, Jake | Research Experience for Undergraduates (REU) Participant | 3 |

Full details of individuals who have worked on the project:

Debra P Peters

Email: debpeter@nmsu.edu

Most Senior Project Role: PD/PI

Nearest Person Month Worked: 2

Contribution to the Project: lead PI, led grass recovery studies, ecosystem modeling

Funding Support: this award

International Collaboration: No

International Travel: No

Brandon Bestelmeyer

Email: bbestelm@nmsu.edu

Most Senior Project Role: Co PD/PI

Nearest Person Month Worked: 1

Contribution to the Project: Leading Goal 1 activities in grassland to shrubland transitions, and participating in ecotone studies of animal dynamics (Goal 2) and regional dynamics (Goal 3)

Funding Support: USDA and this project

International Collaboration: Yes, Mongolia

International Travel: No

Stephanie V Bestelmeyer

Email: stephanie@asombro.org

Most Senior Project Role: Co PD/PI

Nearest Person Month Worked: 4

Contribution to the Project: Director, Asombro Institute for Science Education

Funding Support: this project and others

International Collaboration: No

International Travel: No

Kris M Havstad

Email: khavstad@nmsu.edu

Most Senior Project Role: Co PD/PI

Nearest Person Month Worked: 1

Contribution to the Project: participating in animal studies and multi-stressor studies; leading network collaborations

Funding Support: USDA and this project

International Collaboration: Yes, China

International Travel: No

Hugh C Monger

Email: cmonger@nmsu.edu

Most Senior Project Role: Co PD/PI

Nearest Person Month Worked: 3

Contribution to the Project: leading geomorphology studies under Goal 2

Funding Support: this project

International Collaboration: No

International Travel: No

Steve Archer

Email: sarcher@ag.arizona.edu

Most Senior Project Role: Co-Investigator

Nearest Person Month Worked: 1

Contribution to the Project: Provides scientific expertise on grass-shrub interactions at individual plant scale with a focus on demography and physiology

Funding Support: this award

International Collaboration: No

International Travel: No

Michael C. Duniway

Email: mduniway@usgs.gov

Most Senior Project Role: Co-Investigator

Nearest Person Month Worked: 1

Contribution to the Project: Provides scientific expertise on plant-soil water relationships at individual plant scale with links to hydrology at patch to landscape scales

Funding Support: this award

International Collaboration: No

International Travel: No

Jeffrey E. Herrick

Email: jherrick@nmsu.edu

Most Senior Project Role: Co-Investigator

Nearest Person Month Worked: 1

Contribution to the Project: Provides scientific expertise on developing and using qualitative assessment and quantitative monitoring tools

Funding Support: this award

International Collaboration: Yes, Kenya

International Travel: Yes, Kenya - 0 years, 0 months, 14 days; Iceland - 0 years, 0 months, 14 days; Namibia - 0 years, 0 months, 14 days; China - 0 years, 0 months, 7 days

Gregory S. Okin

Email: okin@ucla.edu

Most Senior Project Role: Co-Investigator

Nearest Person Month Worked: 1

Contribution to the Project: provides scientific expertise in dust and aeolian dynamics, both field studies and simulation modeling

Funding Support: this award

International Collaboration: Yes, Botswana

International Travel: Yes, Botswana - 0 years, 0 months, 14 days

Albert Rango

Email: alrango@nmsu.edu

Most Senior Project Role: Co-Investigator

Nearest Person Month Worked: 1

Contribution to the Project: provides scientific expertise on snowmelt modeling, and collecting long-term climatic data relative to the water cycle

Funding Support: this award

International Collaboration: No

International Travel: No

Oswaldo E. Sala

Email: osvaldo.sala@asu.edu

Most Senior Project Role: Co-Investigator

Nearest Person Month Worked: 1

Contribution to the Project: provides scientific expertise in biodiversity, sustainability, and biogeochemistry of grasslands and shrublands

Funding Support: this award

International Collaboration: Yes, Argentina

International Travel: Yes, Israel - 0 years, 0 months, 7 days

Nathan F. Sayre

Email: nsayre@berkeley.edu

Most Senior Project Role: Co-Investigator

Nearest Person Month Worked: 1

Contribution to the Project: provides scientific expertise on traditional ecological knowledge in rangelands

Funding Support: this award

International Collaboration: No

International Travel: No

Robert L. Schooley

Email: schooley@illinois.edu

Most Senior Project Role: Co-Investigator

Nearest Person Month Worked: 1

Contribution to the Project: Provides scientific expertise on small animal population dynamics and metapopulations

Funding Support: this award

International Collaboration: No

International Travel: No

Heather L. Throop

Email: throop@nmsu.edu

Most Senior Project Role: Co-Investigator

Nearest Person Month Worked: 1

Contribution to the Project: provides scientific expertise in litter decomposition processes and its importance in

the carbon and water cycles

Funding Support: this award

International Collaboration: Yes, Namibia

International Travel: Yes, Namibia - 1 years, 0 months, 0 days

Craig E. Tweedie

Email: ctweedie@utep.edu

Most Senior Project Role: Co-Investigator

Nearest Person Month Worked: 1

Contribution to the Project: provides scientific expertise on cyberinfrastructure (hardware, software) technologies for new uses in ecology

Funding Support: this award

International Collaboration: No

International Travel: No

Enrique R. Vivoni

Email: vivoni@asu.edu

Most Senior Project Role: Co-Investigator

Nearest Person Month Worked: 1

Contribution to the Project: provides scientific expertise in ecohydrology and dynamics of watersheds

Funding Support: this award

International Collaboration: Yes, Mexico

International Travel: Yes, Mexico - 0 years, 4 months, 0 days

Israel del Toro

Email: israedt@gmail.com

Most Senior Project Role: Postdoctoral (scholar, fellow or other postdoctoral position)

Nearest Person Month Worked: 3

Contribution to the Project: working with B. Bestelmeyer on nat dynamics

Funding Support: this award

International Collaboration: No

International Travel: No

Laureano Gherardi

Email: lgherar1@asu.edu

Most Senior Project Role: Postdoctoral (scholar, fellow or other postdoctoral position)

Nearest Person Month Worked: 3

Contribution to the Project: working with Sala on experimental rainfall plots

Funding Support: this award

International Collaboration: No

International Travel: No

Matthew Levi

Email: mrlevi21@nmsu.edu

Most Senior Project Role: Postdoctoral (scholar, fellow or other postdoctoral position)

Nearest Person Month Worked: 6

Contribution to the Project: postdoc working with B. Bestelmeyer to examine relationships between ownership variables and biophysical variables across the Chihuahuan Desert region.

Funding Support: this award and BLM

International Collaboration: No

International Travel: No

Geovany Ramirez

Email: geoabi@gmail.com

Most Senior Project Role: Postdoctoral (scholar, fellow or other postdoctoral position)

Nearest Person Month Worked: 3

Contribution to the Project: working with Peters on KLAS project to use machine learning with long-term data

Funding Support: this award and EAGER funding

International Collaboration: No

International Travel: No

Joel R. Brown

Email: joelbrow@nmsu.edu

Most Senior Project Role: Other Professional

Nearest Person Month Worked: 1

Contribution to the Project: provides expertise on soils and national soils databases; key collaborator with the NRCS

Funding Support: this award

International Collaboration: No

International Travel: No

Dawn Browning

Email: dbrownin@nmsu.edu

Most Senior Project Role: Other Professional

Nearest Person Month Worked: 1

Contribution to the Project: provides expertise in remote sensing and plant phenology

Funding Support: this award and USDA

International Collaboration: No

International Travel: No

Michaela Buenemann**Email:** elabuen@nmsu.edu**Most Senior Project Role:** Other Professional**Nearest Person Month Worked:** 1**Contribution to the Project:** Provides expertise in GIS and spatial analyses**Funding Support:** this award**International Collaboration:** No**International Travel:** No

Nathan Dylan Burruss**Email:** dylanb@nmsu.edu**Most Senior Project Role:** Other Professional**Nearest Person Month Worked:** 6**Contribution to the Project:** working with Peters on shrubland-shrubland transitions**Funding Support:** this award**International Collaboration:** No**International Travel:** No

Libby Grace**Email:** libby@asombro.org**Most Senior Project Role:** Other Professional**Nearest Person Month Worked:** 3**Contribution to the Project:** Science education specialist at Asombro**Funding Support:** this award**International Collaboration:** No**International Travel:** No

Stephanie Haan-Amato**Email:** s.haan-amato@asombro.org**Most Senior Project Role:** Other Professional**Nearest Person Month Worked:** 4**Contribution to the Project:** Science education specialist with Asombro Institute for Science Education**Funding Support:** this award and Asombro**International Collaboration:** No**International Travel:** No

Karen Mabry**Email:** kmabry@nmsu.edu**Most Senior Project Role:** Other Professional

Nearest Person Month Worked: 1

Contribution to the Project: provides expertise in small animal movement studies

Funding Support: this award

International Collaboration: No

International Travel: No

Ryan Pemberton

Email: ryan@asombro.org

Most Senior Project Role: Other Professional

Nearest Person Month Worked: 3

Contribution to the Project: Science education specialist at Asombro

Funding Support: this award

International Collaboration: No

International Travel: No

Marianne Somerday

Email: rink@asombro.org

Most Senior Project Role: Other Professional

Nearest Person Month Worked: 3

Contribution to the Project: Asombro program coordinator

Funding Support: this award and Asombro

International Collaboration: No

International Travel: No

John Anderson

Email: janderso@nmsu.edu

Most Senior Project Role: Technician

Nearest Person Month Worked: 12

Contribution to the Project: LTER site manager responsible for data collection, QA/QC, interactions with scientists and visitors on data issues

Funding Support: this award

International Collaboration: No

International Travel: No

Roxanne Chepsongol

Email: rofranke@nmsu.edu

Most Senior Project Role: Technician

Nearest Person Month Worked: 12

Contribution to the Project: member of LTER field crew

Funding Support: this award

International Collaboration: No

International Travel: No

Yanhua Feng

Email: yf@nmsu.edu

Most Senior Project Role: Technician

Nearest Person Month Worked: 12

Contribution to the Project: soils technician working with Monger

Funding Support: this award

International Collaboration: No

International Travel: No

Bernice Gamboa

Email: bgamboa@nmsu.edu

Most Senior Project Role: Technician

Nearest Person Month Worked: 1

Contribution to the Project: provides office support

Funding Support: this award

International Collaboration: No

International Travel: No

Kyle Gename

Email: kgename@nmsu.edu

Most Senior Project Role: Technician

Nearest Person Month Worked: 12

Contribution to the Project: LTER field technician

Funding Support: this award

International Collaboration: No

International Travel: No

Seth Hall

Email: sethahall08@gmail.com

Most Senior Project Role: Technician

Nearest Person Month Worked: 12

Contribution to the Project: LTER field technician

Funding Support: this award

International Collaboration: No

International Travel: No

Charlene Harrison**Email:** charhrsn@nmsu.edu**Most Senior Project Role:** Technician**Nearest Person Month Worked:** 6**Contribution to the Project:** provides office support, budget and travel support**Funding Support:** this award**International Collaboration:** No**International Travel:** No

Valerie LaPlante**Email:** vlaplante@nmsu.edu**Most Senior Project Role:** Technician**Nearest Person Month Worked:** 4**Contribution to the Project:** provides IT (software) and web page support**Funding Support:** this award and USDA**International Collaboration:** No**International Travel:** No

James Lenz**Email:** jlenz@nmsu.edu**Most Senior Project Role:** Technician**Nearest Person Month Worked:** 4**Contribution to the Project:** IT specialist with the Jornada**Funding Support:** this award and USDA**International Collaboration:** No**International Travel:** No

Gesuri Ramirez**Email:** gesuri@gmail.com**Most Senior Project Role:** Technician**Nearest Person Month Worked:** 6**Contribution to the Project:** worked with Tweedie on eddy flux tower calibration and testing**Funding Support:** this award and UTEP**International Collaboration:** No**International Travel:** No

Kenneth Ramsey**Email:** kramsey@nmsu.edu**Most Senior Project Role:** Technician

Nearest Person Month Worked: 12

Contribution to the Project: Information manager for the Jornada Basin LTER

Funding Support: this award

International Collaboration: No

International Travel: No

Theodore Scott Schrader

Email: schrader@nmsu.edu

Most Senior Project Role: Technician

Nearest Person Month Worked: 6

Contribution to the Project: provides GIS and spatial analysis support

Funding Support: this award and USDA

International Collaboration: No

International Travel: No

Jin Yao

Email: jyao@nmsu.edu

Most Senior Project Role: Staff Scientist (doctoral level)

Nearest Person Month Worked: 6

Contribution to the Project: provides statistical analyses and QA/QC, updating on long term datasets

Funding Support: this award

International Collaboration: No

International Travel: No

Herman Campos

Email: hcampos@nmsu.edu

Most Senior Project Role: Graduate Student (research assistant)

Nearest Person Month Worked: 3

Contribution to the Project: Graduate student working with Heather Throop on decomposition dynamics

Funding Support: this award

International Collaboration: No

International Travel: No

Kristen DaVanon

Email: kdavanon@gmail.com

Most Senior Project Role: Graduate Student (research assistant)

Nearest Person Month Worked: 3

Contribution to the Project: working with Bestelmeyer, Schooley, and Mabry on small animal studies in urban locations near the Jornada

Funding Support: this award

International Collaboration: No

International Travel: No

Josh Haussler

Email: jhaussle@asu.edu

Most Senior Project Role: Graduate Student (research assistant)

Nearest Person Month Worked: 3

Contribution to the Project: graduate student working with Osvaldo Sala on rainfall manipulation experiments

Funding Support: this award

International Collaboration: No

International Travel: No

Owen McKenna

Email: omckenna@luc.edu

Most Senior Project Role: Graduate Student (research assistant)

Nearest Person Month Worked: 3

Contribution to the Project: working with Sala on carbon and nitrogen cycling in playas

Funding Support: this award

International Collaboration: No

International Travel: No

Anna Ortiz

Email: anna.ortizc@gmail.com

Most Senior Project Role: Graduate Student (research assistant)

Nearest Person Month Worked: 3

Contribution to the Project: worked with Craig Tweedie on instrumentation at eddy flux tower site in shrublands

Funding Support: this award and UTEP funding

International Collaboration: No

International Travel: No

Nate Pierce

Email: npierce@arizona.edu

Most Senior Project Role: Graduate Student (research assistant)

Nearest Person Month Worked: 3

Contribution to the Project: working with Archer on grass-shrub interaction study

Funding Support: this award

International Collaboration: No

International Travel: No

Adam Schreiner-McGraw**Email:** apschrei@asu.edu**Most Senior Project Role:** Graduate Student (research assistant)**Nearest Person Month Worked:** 12**Contribution to the Project:** working with Vivoni on hydrology studies**Funding Support:** this award**International Collaboration:** No**International Travel:** No

Mitra Solgi**Email:** msolgi@nmsu.edu**Most Senior Project Role:** Graduate Student (research assistant)**Nearest Person Month Worked:** 2**Contribution to the Project:** updating the Jornada LTER web site**Funding Support:** this award**International Collaboration:** No**International Travel:** No

Julie Schlichte**Email:** julie.marie.schlichte@gmail.com**Most Senior Project Role:** Research Experience for Undergraduates (REU) Participant**Nearest Person Month Worked:** 3**Contribution to the Project:** REU working on arthropod biodiversity with B. Bestelmeyer and I. del Toro**Funding Support:** this award**International Collaboration:** No**International Travel:** No**Year of schooling completed:** Junior**Home Institution:** UTEP**Government fiscal year(s) was this REU participant supported:** 2015

Jake Stoner**Email:** jakestoner21@gmail.com**Most Senior Project Role:** Research Experience for Undergraduates (REU) Participant**Nearest Person Month Worked:** 3**Contribution to the Project:** REU student working with Sala on rainfall manipulation experiments**Funding Support:** this award**International Collaboration:** No**International Travel:** No**Year of schooling completed:** Junior**Home Institution:** Arizona State University

Government fiscal year(s) was this REU participant supported: 2015

What other organizations have been involved as partners?

| Name | Type of Partner Organization | Location |
|--|---|------------------|
| Arizona State University | Academic Institution | Tempe, AZ |
| Asombro Institute for Science Education | Other Nonprofits | Las Cruces, NM |
| University of California-Los Angeles | Academic Institution | Los Angeles |
| University of Illinois | Academic Institution | Urbana-Champaign |
| University of Texas-El Paso | Academic Institution | El Paso, TX |
| Bureau of Land Management | Other Organizations (foreign or domestic) | Las Cruces, NM |
| Center for Applied Remote Sensing in Agriculture, Meteorolog | Academic Institution | Las Cruces, NM |
| Institute for Natural Resource Analysis and Management | Academic Institution | Las Cruces, NM |
| US Geological Survey | Other Organizations (foreign or domestic) | Moab, UT |
| USDA ARS, Jornada Experimental Range | Other Organizations (foreign or domestic) | Las Cruces, NM |
| USDA NRCS | Other Organizations (foreign or domestic) | Las Cruces, NM |
| University of Arizona | Academic Institution | Tucson, AZ |
| University of California-Berkeley | Academic Institution | Berkeley, CA |

Full details of organizations that have been involved as partners:

Arizona State University

Organization Type: Academic Institution

Organization Location: Tempe, AZ

Partner's Contribution to the Project:

Financial support

In-Kind Support

Facilities

Collaborative Research
Personnel Exchanges

More Detail on Partner and Contribution: ASU provides office and lab facilities for Sala and Vivoni and their students

Asombro Institute for Science Education

Organization Type: Other Nonprofits
Organization Location: Las Cruces, NM

Partner's Contribution to the Project:
Collaborative Research
Personnel Exchanges

More Detail on Partner and Contribution: Asombro operates the Jornada Basin schoolyard LTER program

Bureau of Land Management

Organization Type: Other Organizations (foreign or domestic)
Organization Location: Las Cruces, NM

Partner's Contribution to the Project:
In-Kind Support
Facilities
Collaborative Research

More Detail on Partner and Contribution: BLM provides legacy data and photos of range sites near the Jornada

Center for Applied Remote Sensing in Agriculture, Meteorolog

Organization Type: Academic Institution
Organization Location: Las Cruces, NM

Partner's Contribution to the Project:
In-Kind Support
Facilities
Collaborative Research

More Detail on Partner and Contribution: CARSAME provides imagery and analyses for remotely sensing applications

Institute for Natural Resource Analysis and Management

Organization Type: Academic Institution
Organization Location: Las Cruces, NM

Partner's Contribution to the Project:
Facilities

More Detail on Partner and Contribution: INRAM provides equipment and supplies for soil analyses

US Geological Survey

Organization Type: Other Organizations (foreign or domestic)

Organization Location: Moab, UT

Partner's Contribution to the Project:

Financial support

In-Kind Support

Facilities

Collaborative Research

Personnel Exchanges

More Detail on Partner and Contribution: USGS provides salary, office, and lab support for Duniway

USDA ARS, Jornada Experimental Range

Organization Type: Other Organizations (foreign or domestic)

Organization Location: Las Cruces, NM

Partner's Contribution to the Project:

In-Kind Support

Facilities

Collaborative Research

Personnel Exchanges

More Detail on Partner and Contribution: Jornada Basin LTER office and numerous PIs' offices are housed in the USDA bldg. The Jornada land base is primary site for LTER research.

USDA NRCS

Organization Type: Other Organizations (foreign or domestic)

Organization Location: Las Cruces, NM

Partner's Contribution to the Project:

Collaborative Research

Personnel Exchanges

More Detail on Partner and Contribution: Supports collaborative research through Joel Brown, an NRCS employee

University of Arizona

Organization Type: Academic Institution

Organization Location: Tucson, AZ

Partner's Contribution to the Project:

Financial support

In-Kind Support

Facilities

Collaborative Research

Personnel Exchanges

More Detail on Partner and Contribution: UA provides office and lab support and salary for Archer and his students

University of California-Berkeley

Organization Type: Academic Institution

Organization Location: Berkeley, CA

Partner's Contribution to the Project:

Financial support

In-Kind Support

Facilities

Collaborative Research

Personnel Exchanges

More Detail on Partner and Contribution: UC-Berkeley provides office and lab support and salary for Sayre and his students

University of California-Los Angeles

Organization Type: Academic Institution

Organization Location: Los Angeles

Partner's Contribution to the Project:

Financial support

In-Kind Support

Facilities

Collaborative Research

Personnel Exchanges

More Detail on Partner and Contribution: UCLA provides office and lab support and salary for Okin and his students

University of Illinois

Organization Type: Academic Institution

Organization Location: Urbana-Champaign

Partner's Contribution to the Project:

Financial support

In-Kind Support

Facilities

Collaborative Research

Personnel Exchanges

More Detail on Partner and Contribution: University of Illinois provides office and lab support and salary for Schooley and his students

University of Texas-El Paso

Organization Type: Academic Institution

Organization Location: El Paso, TX

Partner's Contribution to the Project:

Financial support

In-Kind Support

Facilities

Collaborative Research

Personnel Exchanges

More Detail on Partner and Contribution: UTEP provides office, lab, and salary support for Tweedie and his students

What other collaborators or contacts have been involved?

Nothing to report

Impacts

What is the impact on the development of the principal discipline(s) of the project?

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 can exacerbate patchiness in soil resources and provide a positive feedback to continued shrub dominance has stimulated research at the Jornada and other sites globally. More recently, our landscape linkages framework expands on the plantinterspace model to explicitly include a range of interacting spatial scales with a focus on transport processes that connect patches. This framework has been used to explain historic patterns that were unaccounted for by the single scale plantinterspace model of Schlesinger et al. (1990). The framework has also been applied to grass recovery in desertified shrublands following a 5year wet period, and to explain longterm grass dynamics and threshold behavior following drought. The application of this crossscale approach to broader scales has implications for continentalscale ecology and the development of environmental observatories and networks to address broadscale questions. The Jornada Program has also pioneered a new paradigm for ecosystem services. Previously, ecosystem services were studied from the ability of ecosystems to supply them. The new paradigm focuses on reconciling supply and demand of ecosystem services.

What is the impact on other disciplines?

Jornada LTER research on state changes has promoted an understanding by soil scientists about the properties of soils, including soil moisture, temperature, and microbial dynamics, in aridlands that influence their resilience and resistance to future disturbance. LTER research has been particularly important in allowing geomorphologists, ecohydrologists, and soil scientists to explore the feedbacks between soil properties, terrain conditions, and

vegetation cover across a range of temporal and spatial scales. Range managers are using LTER research findings to develop stateandtransition models matched to specific ecological sites occurring over millions of acres of land in the western US and globally. The identification of early indicators of state changes for diverse terrestrial, aquatic, and marine ecosystems is being aided by Jornada longterm data and analyses. Jornada research is contributing to the development of Earth System Science and the understanding of phenomena that link ecosystems to global environmental change. Specific examples include interactions between desertification and the generation and export of dust to the atmosphere that feeds back to terrestrial ecosystem processes. Recent research on inorganic carbon at the Jornada is increasing knowledge of terrestrial biomineralization and the carbon cycle at the global scale. Jornada research is actively supporting the development of remote sensing technology and analysis. Remote sensing in

aridlands has traditionally been constrained by technical difficulties (i.e., predominance of the bare soil surface signal), but the vast expanses of relatively inaccessible arid lands with significant largescale variation is demanding better remote sensing technologies. Ground truth data and extensive processlevel studies available at the Jornada allow crossreferencing with imagery from aerial, including drones and UAVs, and satellite platforms. There are few such wellstudied locations in arid and semiarid regions of the world, and Jornada will continue to make important contributions to this field. The special issue in *Frontiers in Ecology and Environment* published in 2015 and led by the Jornada Program is an example of interdisciplinarity. For example, in this issue the Jornada Program described a new framework for legacies that encompasses ideas from the geological sciences and plant physiology to the social sciences.

What is the impact on the development of human resources?

The Jornada program supports graduate and undergraduate students from numerous institutions and departments within those institutions, and attracts postdocs and visiting scientists from around the world. NMSU, UTEP, ASU, and UA are all minority, Hispanic-serving institutions, and we routinely include minority and female students in our program. In addition, Jeff Herrick has been an active mentor of the ESA SEEDS program for many years. This program recruits and supports students from underrepresented minority groups in ecology.

What is the impact on physical resources that form infrastructure?

Activities at the Jornada have been leveraged extensively in other research projects and to attract other national research networks that have helped to build new infrastructure, including instrumentation networks and coordinated observation sites. Currently, the Jornada Program is engaged in 10 additional research networks that link sites across the US and around the globe. These include the Long-term Agro-ecosystem Research Network, the National Wind Erosion Research Network, and the USDA Climate Hub Network. The Jornada Program has built a well-replicated rainfall manipulation facility, which is unique in the world and has attracted numerous scientists who took advantage of the facility and launched additional experiments. For example, Diana Wall and Zack Sylvain from Colorado State University studied the effects of our rainfall manipulations on nematode populations. This research was recently published in *Global Change Biology*. The Jornada Program has been successful in receiving resources to build additional facilities that gather and make data available online at the research site. Consequently, the use of the site has increased, both locally and by visiting scientists and classes.

What is the impact on institutional resources that form infrastructure?

The Jornada as a large research program on the campus of NMSU is able to have input on future faculty hires and expansion in the areas of ecology and environmental science by the university.

What is the impact on information resources that form infrastructure?

The Jornada was the cofounder of the EcoTrends Project where the goal is to make longterm data and derived data products from many sites easily accessible and usable by others. The Jornada maintains and upgrades the EcoTrends web site, and has focused on making the longterm data easily used by high school students.

What is the impact on technology transfer?

The Jornada program continues conducting workshops for land management personnel on techniques for monitoring and assessing land status and need for conservation practices. A key audience has been personnel with the Natural Resource Conservation Service that provides technical support to the private land ranchers and farmers across the US. The Jornada program continued in 2015 its formal, individual state agreements with Cooperative Extension Services in New Mexico, Nevada, Utah, Arizona and Hawaii to specifically collaborate to deliver science based information to private land managers through over a dozen Extensionled workshops across these 5 states. An agreement through the ARS based in Davis, California, and linked to the University of California system accomplishes a similar goal for people managing agricultural lands in California. The Jornada Program has developed the Automatic Rainfall Manipulation System (ARMS), which is a system that includes rainout shelters that intercept 50 or 80% of incoming PPT, store water temporarily in tanks connected to irrigation systems and transfer the water to the +50 or

+80% of ambient PPT water addition treatments. The ARMS system has been patented by ASU. The Jornada established a specific cooperative agreement with the Bureau of Land Management to transfer science-based assessment, monitoring and inventory methods for monitoring hundreds of millions of acres of arid and semiarid public rangelands across the western US, including Alaska.

What is the impact on society beyond science and technology?

Human populations and land use patterns are continuing to change rapidly. Jornada research provides a basic understanding of the limits to management of livestock in these systems, and the need to match livestock production systems to these limits. Moreover, Jornada research on changing land use patterns, biodiversity, air and water quality, climate change, and other aspects of human-environment interactions are being used in regional to global efforts to understand and manage for human activities in arid systems beyond livestock production. LTER research findings have been used in the development of assessment and monitoring methods to evaluate the status of arid and semiarid land, and the ability of this land to provide food and fiber to humans. Much of the American West is composed of these lands, thus there is substantial debate about the appropriateness of particular land uses and their impacts on ecosystem and economic sustainability. Our applications provide tools that are used by regulatory and land management agencies as well as by private land owners. Our highly successful schoolyard LTER program works to increase local K12 science literacy while also providing models of K12 science education that can be applied more broadly. We operate in a region of the US with a largely poor, minority population. Las Cruces public schools 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, underserved population. Our middle and high school Data Jam competition is now being replicated at several other sites, thus increasing K12 science literacy well beyond our region. These programs include both classroom and field experience.

Changes/Problems

Changes in approach and reason for change

Nothing to report.

Actual or Anticipated problems or delays and actions or plans to resolve them

Nothing to report.

Changes that have a significant impact on expenditures

Nothing to report.

Significant changes in use or care of human subjects

Nothing to report.

Significant changes in use or care of vertebrate animals

Nothing to report.

Significant changes in use or care of biohazards

Nothing to report.