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Federal Agency and Organization Element to Which Report is Submitted:	4900
Federal Grant or Other Identifying Number Assigned by Agency:	1235828
Project Title:	LTER: Long-Term Research at the Jornada Basin (LTER-VI)
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
Recipient Organization:	New Mexico State University
Project/Grant Period:	12/01/2012 - 11/30/2018
Reporting Period:	12/01/2016 - 11/30/2017
Submitting Official (if other than PD\PI):	Debra P Peters Principal Investigator
Submission Date:	09/29/2017
Signature of Submitting Official (signature shall be submitted in accordance with agency specific instructions)	Debra P Peters

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 at the Jornada

Grassland to shrubland transitions: this is the classic example of desertification dynamics found in arid and semiarid ecosystems globally.

1. A key problem addressed by the Stressor 2 experiment is to determine whether threshold dynamics in grass cover (grassland collapse) could be reproduced experimentally to better understand how historical transitions occurred. We collected a final measurement on the Stressor 2 experiment in fall of 2016, representing 20 years since the initiation of the experiment to examine the effects of severe grazing and shrub removal on grass recovery.

Shrubland to grassland transitions: the recent increase in native perennial grasses in some desertified shrublands suggests that climate variability may initiate state change reversals, while long-term data show that the key recovery processes differ by grass species, and that grasses in mesquite shrublands are more

responsive than in other shrub-dominated systems to extended wet periods (Peters et al. 2014). The infrequent nature of exogenous phenomena, such as El Niño, requires long-term manipulative experiments.

1. We are continuing a long-term experiment of rainfall manipulations (80% reduced PPT, ambient, 80% increased PPT) since 2007 to: (1) test hypotheses about thresholds in the ecosystem responses to precipitation, and (2) unravel the mechanisms behind observed changes.
2. We are continuing an increased precipitation variability experiment, initiated in 2009, where we maintain constant mean precipitation. The goal of this experiment is to understand the long-term effects of precipitation variability and disentangle the effects of precipitation variance from those of precipitation amount on ANPP and functional diversity.
3. We are continuing long-term monitoring of NPP at 15 locations across the Jornada Basin and developing a perennial grass response to precipitation index that depends on local biotic and physical properties instead of ecosystem type.

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

1. We are determining the explanatory variables related to changes in shrub species composition beginning in the 1850s across the Jornada, with a focus on the eastern bajada. Interactions among shrub species have been little studied (Peters et al. 2016). Although current paradigms state that each species dominates on its own soil texture-geomorphology zone, historic maps show changes in shrub dominance accompanied by or preceded by dynamic soil texture at similar locations.
2. We have quantified seasonal patterns of phenological states for different shrub species (mesquite, creosotebush, tarbush) through the use of phenological cameras on the east bajada. Phenocam imagery, field measurements and UAV-based species maps have been integrated to determine species-level greenness and relate it to leaf area index to obtain parameters such as vegetation cover fraction and optical transmission coefficient for use in a distributed ecohydrologic model. Ecosystem state scenarios are under construction to evaluate the model response to historical shrubland to shrubland transitions, including effects on soil water, runoff and evapotranspiration.
3. The link between turbulent fluxes, soil moisture, and soil temperature is being explored in the footprints of two eddy covariance towers. The shrub composition within the time-variable footprint was found to be a determinant of the measured evapotranspiration and the fraction attributed to shrub transpiration (Anderson and Vivoni, 2016). To date, phenological trends of key plant species (phenocam, hyperspectral, and phenophase measurements), and landscapes (hyperspectral and phenocam measurements) have been compiled. These show both marked seasonal and inter-annual differences between shrub species and how they respond to drought and other disturbances. Preliminary analyses linking species to landscape phenological trends with other ecosystem properties and processes show relatively strong linkages, highlighting that species specific cover and phenological trends play key roles in ecosystem function

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.

1. We are using a soil water model 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 of lovegrass.

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

1. 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.
2. Live-trapping grids for desert rodents and non-invasive camera traps for lagomorphs and mesocarnivores were established across shrubland-grassland ecotones 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, fire patterns and allotment dynamics in private land holdings in the landscapes surrounding the Jornada-LTER site.

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 sixth annual Data Jam competition for middle school students in New Mexico, shared the Data Jam model with Education and Outreach coordinators across the larger LTER network, and provided materials and advice to scientists and educators at BES and LUQ who subsequently hosted three Data Jams in Maryland, New York, and Puerto Rico.
3. Developed cooperative agreements with national and international organizations.
4. Led or co-led six 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 US.
5. Continued working with land management agencies to promote adoption of a common set of rangeland monitoring protocols based in part on JRN research.
6. Continued development of the JournalMap website.
7. Continued development of a Land-Potential Knowledge System (Herrick et al. 2016) with USAID support, and released two mobile apps for soil and vegetation data capture.

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

1. Reviewed and updated all metadata stored within the Jornada data catalog.
2. Facilitated analysis and visualization of Ecotrends data
3. Continued development of the Knowledge, Learning, Analysis System (KLAS)
4. Maintained and enhanced the computational resources and infrastructure of the Jornada to support its research collaborations
5. Upgraded web and database servers software stack to improve security, stability, and performance
6. Developed faceted search interfaces for datasets and research
7. Deployed solution to allow portions of the Jornada website to have their own themes

8. Secured all Jornada websites using SSL

Specific Objectives:

GOAL 1: To provide new understanding of state changes within geomorphic units at the Jornada

Grassland to shrubland transitions:

1. We are re-measuring 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 long-term 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. We continued to monitor these experiments in 2016-17.

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 inter-annual and long-term changes in rainfall. (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 historical transition pathways, we are exploring how spatial-temporal patterns in shrub species varies 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 are using 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.
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. Model calibration and testing activities have been completed using a six-year record at the watershed. The model has been enhanced by adding a channel transmission loss component that has been observed in the watershed from multiple lines of evidence (soil moisture records, water balance estimates, field hydraulic tests). The implications of hillslope and channel properties on the production of runoff from the watershed are under evaluation as means for understanding the downstream consequences of vegetation state change.

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 at the SCAN site.

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) evaluate potential for top-down versus bottom-up trophic cascades.

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

1. The broad goal is to understand how social and ecological processes interact to determine the distribution of ecological states at the regional scale.

2. We are engaging 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 project.

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 other LTER sites interested in adopting and 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

1. Update all metadata stored within the LTER Data Catalog for completeness and accuracy

2. Continue to develop EcoTrends website
3. Complete phase 2 development which uses a combination of the existing EcoTrends database and the LTER Data Portal
4. Plan for phase 3 development which will use the LTER Data Portal as the data source and repository instead of the old EcoTrends database
5. Continue development of KLAS
6. Infrastructure upgrades
7. Expand central storage capacity
8. Increase the bandwidth to the field headquarters
9. Upgrade Windows 2003 servers as it is no longer supported
10. Upgrade and consolidate virtualization environment
11. Deploy security appliance (firewall)
12. Implement a consolidated backup solution to protect computational resources, research data, and associated metadata for central servers, storage, desktops, and laptops
13. Upgrade Drupal core and modules for all Drupal-based websites to mitigate security vulnerabilities and improve performance and stability
14. Secure all Jornada websites using HTTPS
15. Use separate themes for portions of the Jornada website
16. Develop search interfaces for datasets and research projects that allow tunneling into search results
17. Update the JRN LTER bibliography interface

Significant Results:

GOAL 1: To provide new understanding of state changes within geomorphic units at the Jornada

Grassland to shrubland transitions:

1. Even after 20 years with no grazing, grass cover continues to increase, with no sign of saturation (leveling off), from the initial, moderately grazed state (Fig. 1). The impact of heavy grazing is still substantial, with one plot now clearly exhibiting threshold behavior (a lack of trend toward recovery). The effects of shrub removal continue to be undetectable in the heavy grazed treatments, but are detectable in the 20-y ungrazed plots, suggesting that the effects of shrubs on grass recovery are obvious only at relatively high shrub cover.

Shrubland to grassland transitions:

1. Increased precipitation resulted in a significant increase in grass productivity and a decline in shrub productivity whereas drought had the opposite effect. Grass and shrub responses depended on the time of exposure to chronic resource alterations, and there are discontinuities in the effect of time. For example, total and grass production show no effect of experimental drought after one year, the effect increased for the next 3 years and stabilized from year 3 to 8 when grass production collapsed (Fig 2). Therefore, different conclusions could have been drawn if we had run the experiment for 1, 3 or 8 years; highlighting the importance of long-term experimentation and the value of this LTER project.

2. The eight-year enhanced-precipitation variability experiment showed a strong negative effect of precipitation variability on total ANPP that was significant by the third year and increased until year 6 (Fig 2). Increased precipitation variability benefited shrubs, but their positive response was overshadowed by the negative response of grasses until year 6 (Fig 2). The declining total ANPP trend reversed in 2014-16, the last two years of the experiment.

3. Our analyses of long-term NPP at the 15 locations have focused on perennial grass response in wet vs. dry sequences of years. We are developing a perennial

grass response index that is related to soil texture properties (depth to caliche) and biotic properties (initial grass biomass, herbaceous cover) at each location. These location-based properties allow grass recovery to be predicted regardless of the ecosystem type.

Shrubland to shrubland transitions:

1. Results from our six-year record of simultaneous water balance and flux measurements in the Tromble Weir watershed yielded the first documentation of significant channel percolation losses on an arid piedmont slope (Fig. 3). The closure error in monthly water balance calculations (precipitation, soil moisture storage change, evapotranspiration, and runoff) was linked to channel losses through multiple lines of evidence, including comparisons of hillslope and channel soil moisture records, measurements of channel hydraulic conductivity, estimates of streamflow losses from internal flume measurements and the use of the COSMOS soil moisture sensor. We established a relationship between monthly rainfall and percolation that can be used to extrapolate in space (to other first-order watersheds on the east bajada) and time (to the long-term precipitation record).

2. Deep percolation (mm/month) over a century (1915-2016) was estimated for arid first-order watersheds commonly found in the Jornada basin. (Fig. 3 from Schreiner-McGraw and Vivoni (2017)). As a result of the importance of this hydrologic process to the regional aquifer, the historical changes in vegetation state in these watersheds are anticipated to affect both runoff production and groundwater recharge.

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

1. Measurements of soil moisture of the banded vegetation zone at the SCAN site reveal that the dune has least soil moisture followed by the bare zone and the tobosa grass zone that developed because the linear dune is perpendicular to runoff and forms a dam that collects water. The dune has the highest temperatures followed by the grass and bare zone.
2. Total biomass of desert rodents depends on an interaction between shrub cover and precipitation with more rodent biomass produced on grasslands following droughts, which may increase in southwestern United States. Granivores were mostly core species responding with a lag of up to 1 year to ANPP, whereas folivores included transient species which responded to lagged precipitation at broader spatial scales via spillover dynamics (Fig. 4)

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

1. We completed and published an analysis of regional fire-landscape relationships and showed that fires are more likely on certain landforms, particular those that have a higher water holding capacity.

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

1. A total of 21,221 K-12 students, 819 teachers, and 560 other adults participated in 13 field trips, 761 one-hour classroom/schoolyard lessons, 6 teacher workshops, and 10 family events, where they learned about JRN research by participating in hands-on, inquiry-based activities. Seven graduate students and REUs contributed more than 30 hours to help provide background information and assist with classroom lessons and public events.
2. The Desert Data Jam competition was held in April 2017. In total, 417 middle school students from southern New Mexico participated in the Desert Data Jam.

The top projects from each school (59 projects total, 127 students) participated in the final competition on April 26 and 27. JRN staff also assisted other LTER site educators, who subsequently hosted spring 2017 Data Jam competitions in Maryland, New York, and Puerto Rico.

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.
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 via the Google Play and Apple App Stores.
7. Increased the number of graduate students conducting JRN related research through summer fellowship program and Desert Ecology Class in 2017, with 13 new graduate students, and 13 returning graduate students participating this year.
8. Six undergraduate REU students and an undergraduate research fellow also participated in Jornada research in 2017, including attending the annual Desert Ecology Class.

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

1. Upgraded all Drupal-based websites to address security vulnerabilities and to improve performance and stability.
2. Increased bandwidth to field station to 40 MB using wireless backhaul
3. Deployed and enforced use of SSL certificates to all Jornada websites to improve security
4. Developed search interfaces that allows users to tunnel into search results
5. Deployed Domain Access to allow custom themes for JRN LTER portion of website.

Key outcomes or Other achievements:

GOAL 1: To provide new understanding of state changes within geomorphic units at the Jornada

Grassland to shrubland transitions:

1. A paper is in preparation that outlines results from the NEAT reanalysis. Two UCLA students (Avishesh Neupane and Junzhe Zhang) participated in independent research at UCLA with Professor Okin for University credit.

Shrubland to grassland transitions:

1. Recent results from the 11 year manipulations of precipitation amount dramatically changed our understanding of ecosystem responses to changes in precipitation. First, the effects of long-term alteration of precipitation are opposite in grasses and shrubs. Grasses decline with drought and increase in wet treatments; shrubs had the opposite response. Our new vision sees the response to climate change as driven by species interactions resulting from differential sensitivity to precipitation amount instead of direct effects of precipitation. Second, time since alteration of precipitation affects the response of grasses and shrubs. Third, the response to changes in precipitation is asymmetric: effects of drought do not inform response to wet conditions.

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 historical 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.
2. To identify the controls on the channel transmission losses in upland watersheds of the eastern bajada, the distributed ecohydrological model is being tested under different combinations of soil and vegetation parameters that can be affected by vegetation state transitions. A series of vegetation scenarios with the calibrated model will be used to determine the effect of dynamically changing landscapes on water yield and groundwater recharge from the first-order watersheds.

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. Our long-term monitoring showed that shrub encroachment did not create a degraded landscape characterized by a reduction in total rodent biomass, but this outcome could be vulnerable to climate change and a future with more droughts in the southwestern US. We also demonstrated how core-transient dynamics contribute to bottom-up regulation for desert rodents in dynamic drylands.

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

1. The results of the BLM study will advance our understanding of how social-ecological interactions impact the trajectories of Chihuahuan Desert landscapes. The MBG 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 of fire distribution, effects, and interactions with climate.

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

1. During the 2016-2017 performance period 21,221 K-12 students gained increased understanding of the Chihuahuan Desert and current research being conducted by LTER scientists.
2. More than 400 students gained skills both interpreting and then communicating large, long-term, complex datasets to nonscientists through Data Jam competitions at their own schools.

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

1. Updated bibliography interface to use biblio module pages instead of views and to allow secondary sort (author, title)
2. Migrated Aegir and Jornada website to new web and database servers with updated software stack to improve security, performance, and stability
3. Deployed external facing DNS servers to improve access to Jornada websites from off-campus and correct issues related to NMSU blocking DNS from off-campus
4. Deployed Drupal 8 for new website development and to allow testing of migration of the Jornada website and DEIMS to Drupal 8

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

1. 21,221 K12 students have been trained with an increased understanding of the Chihuahuan Desert and current research being conducted by LTER scientists.
2. More than 400 students have gained skills in interpreting and then communicating large, long-term, complex datasets to nonscientists through Data Jam competitions at their own schools.
3. Six undergraduate students were provided professional development through our summer program, including two with REU fellowships.
4. A total of 14 graduate students were trained as part of our summer and yearlong graduate research assistantship program.
5. Twelve additional graduate students and an undergraduate student (in addition to the students receiving financial support mentioned above) also participated in our Desert Ecology class for undergraduates and graduate students in summer 2017.

*** How have the results been disseminated to communities of interest? If so, please provide details.**

GOAL 1: To provide new understanding of state changes within geomorphic units at the Jornada

Results from this Goal were disseminated through presentations at local, national and international meetings and seminars. These include one presentation at the 2017 Ecological Society of America Annual Meeting, four presentations at the 2016 American Geophysical Union Fall Meeting, four presentations at the 2017 American Geophysical Union Fall Meeting, and eight invited presentations at institutions across the United States, Mexico and in London, UK.

1. The new results were disseminated to regional stakeholders via informal interactions and presentations to BLM staff.

2. Results about the effects of long-term increases and decreases in precipitation on the balance between grasses and shrubs have been reported during the last year in seminars at Harvard University, Colorado State University, Imperial College London, Purdue University, University of New South Wales, Centro de Ecología Xalapa México and King's College London.

3. Results have been disseminated to communities in the geological and ecological sciences, with participation in cross-site shrubland comparisons (Biederman et al., in review).

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

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

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

1. 21,221 K12 students have been trained with increased understanding of the Chihuahuan Desert and current research being conducted by LTER scientists.
2. More than 400 students have gained skills both interpreting and then communicating large, long-term, complex datasets to nonscientists through Data Jam competitions at their own schools.
3. Participation of both undergraduate and graduate students based locally and from Universities across the USA has increased through our REU, graduate fellowship and Desert Ecology Course.

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

1. DEIMS Repository: http://github.com/lterjrn/deims
2. Jornada source code enhancements to DEIMS are shared with the wider DEIMS and Drupal communities in the repository
3. DEIMS Project Page: http://www.drupal.org/project/deims
4. Jornada bug fixes and information related to DEIMS are shared with wider DEIMS and Drupal communities within the page
5. LTER Data Portal: https://portal.lternet.edu/nis/browseServlet?searchValue=JRN
6. EcoTrends Data Portal: http://www.ecotrends.info
7. Jornada Data Catalog: http://jornada.nmsu.edu/lter/data
8. Jornada Data Explorer: http://jornada.nmsu.edu/dataexplorerdashboard

9. Jornada research data and metadata are made available from multiple portals
10. DrupalCon Austin June 2014
11. DEIMS Workshop: http://austin2014.drupal.org/session/deimsdrupalprofileecologicaldata
12. Presentation and discussion of DEIMS to wider Drupal community
13. Science on Drupal Workshop: http://neworleans2016.drupal.org/bof/sciencedrupal
14. Science on Drupal Workshop: http://austin2014.drupal.org/bof/sciencedrupal
15. Birds of a feather sessions on Drupal's role in supporting the sciences and how agencies and research groups can share challenges and successes and get wider participation in science related Drupal development efforts
16. Federation of Earth Science Information Partners (ESIP) Conference July 2014
17. Security Lab: http://commons.esipfed.org/node/2558
18. Maps and Visualization Lab: http://commons.esipfed.org/node/2559
19. Drupal Working Group (hosted DrupalCon BOF session), hosted training labs and facilitated discussions begun at DrupalCon on how we can leverage one another's work within Drupal to avoid duplication

*** 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 at the Jornada

Grassland to shrubland transitions:

1. We are gathering the final (20 year) measurement from the ThreshEx grazing-shrub removal study.

Shrubland to grassland transitions:

1. We are comparing responses during the 2004-2008 wet period and recovery (2009-2016) with a previous wet period (1984-1988) and recovery (1989-1999), 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 are continuing the long-term experiments where we have manipulated the amount and variability of precipitation.
3. We will continue an experiment where we are simultaneously manipulating precipitation and the community of soil microorganisms. Precipitation manipulations include: (1) drought with a probability of occurrence of 1/100 years; (2) drought with an occurrence of 1/10 years; (3) control; (4) wet conditions with an occurrence in 1/10 years and (5) wet conditions with a probability of occurrence of 1/100 years. Microcosms with three different microfauna manipulations will be nested within the precipitation manipulations experiments. Microfauna treatments are: (1) defaunated soils; (2) defaunated soils plus herbivore nematodes and (3) defaunated soils plus herbivore and carnivore nematodes.

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 measuring phenological changes and runoff response using cameras, 3) a new network of micrometeorological sensors for quantifying differences in microclimates within the watershed, and 4) evaluating long-term simulations using the spatially-distributed approach that accounts for changes in shrubland 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. Additional phenocam observations will be deployed and similar technology used to quantitatively determine channel runoff.

4. We will process and analyze net ecosystem exchange observations from the long-term eddy covariance record and relate these to phenological measurements. Additional effort will be placed on measuring soil carbon storage and soil carbon fluxes to quantify the watershed carbon balance.
5. We will use time series data from our eddy covariance tower, robotic tram system for measuring spectral reflectance, micrometeorological network, phenocams, phenophase monitoring to explore the biophysical and species-specific controls of land-atmosphere fluxes.

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 will integrate data from the desert rodent and the camera trap studies to determine whether spatiotemporal variation in consumer abundances not explained by bottom-up effects is explained by predator activity and top-down effects. We also are adding an assessment of predation risk by prey and how their landscape of fear influences abundance patterns across shrub gradients.

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

1. Complete analyses of 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

1. 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, two family education events, and the 2018 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

1. Continue KLAS development
2. Automate processes to QA/QC and update website with data and associated metadata in a more timely fashion using R scripts and web services
3. Redesign Jornada Basin LTER website, including new collaborative projects pages to describe current JRN research efforts
4. Automate processes to QA/QC data and update website data and metadata in a more timely fashion using R scripts and web services (Shiny)
5. Enhance number and variety of data-visualization options on the LTER website, including automated and rapid display of standard datasets (e.g. rainfall) and on-demand display of core datasets
6. Integrate web map with data catalog
7. Replace backup target storage system (fiber channel SAN) to support disk-based backups
8. Evaluate paths to migrate Jornada website and DEIMS from Drupal 7 to Drupal 8

Supporting Files

Filename	Description	Uploaded By	Uploaded On
Figure1_wSummary.pdf	Figure 1. (top) Grazing intensity in 0.5 ha control and grazed paddocks over time, and (bottom) Long-term trajectories of Bouteloua eriopoda foliar cover in control and treatment paddocks.	Debra Peters	09/26/2017
Figure2_wSummary.pdf	Figure 2. Long-term manipulation of precipitation amount (A-E) and precipitation inter-annual variability (F-J).	Debra Peters	09/26/2017
Figure3_wSummary.pdf	Figure 3. (a) Annual percolation estimates at three rain gauge sites, along with annual rainfall from the Jornada Headquarters site, and (b) Geomorphic regions in the JER with locations of rain gauges and all first-order watersheds on the piedmont slope derived using a 10-m digital elevation model.	Debra Peters	09/26/2017

Filename	Description	Uploaded By	Uploaded On
Figure4_wSummary.pdf	Figure 4. Interactive effects of summer precipitation (1-year lag) and shrub encroachment on total rodent biomass at Jornada Basin LTER.	Debra Peters	09/26/2017

Products

Books

Soil Science Division Staff (2017). *Soil Survey Manual - USDA Handbook 18* Ditzler, C, Scheffe K, and Monger HC. Government Printing Office. Washington, D.C.. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Book Chapters

Archer, SR, Andersen EM, Predick KI, Schwinning S, Steidl RJ, and Woods SR (2017). Woody plant encroachment: causes and consequences. *Rangeland Systems: Processes, Management and Challenges* Briske DD. Springer. New York, USA. . Status = PUBLISHED; Acknowledgement of Federal Support = Yes ; Peer Reviewed = Yes

Bestelmeyer, BT, Ash AJ, Brown JR, Densambuu B, Fernandez Gimenez ME, Johanson J, Levi MR, Lopez DR, Rumpff L, Peinetti HR, and Shaver PL (2017). State and transition models: Theory, applications, and challenges. *Rangeland Systems: Processes, Management and Challenges* Briske, DD. Springer. 303. Status = PUBLISHED; Acknowledgement of Federal Support = Yes ; Peer Reviewed = Yes

Sala, OE, Vivanco L, and Flombaum P (2017). Grassland Communities and Ecosystems. *Reference Module in Life Sciences* Elsevier. . Status = PUBLISHED; Acknowledgement of Federal Support = Yes ; Peer Reviewed = Yes ; ISBN: 978-0-12-809633-8.

Sala, OE, Yahdjian L, Havstad KM, and Aguiar MR (2017). Rangeland ecosystem services: nature´s supply and humans´ demand. *Rangeland Systems: Processes, Management and Challenges* Briske DD. Springer. New York, USA. 467. Status = PUBLISHED; Acknowledgement of Federal Support = Yes ; Peer Reviewed = Yes

Inventions

Journals or Juried Conference Papers

Bagchi, S, Singh NJ, Briske DD, Bestelmeyer BT, McClaran MP, and Murthy K (2017). Quantifying long term trajectories of plant community change with movement models: implications for ecological resilience. *Ecological Applications*. 27 488. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Bestelmeyer, BT, Williamson JC, Talbot CJ, Cates GW, Duniway MC, and Brown JR (2016). Improving the effectiveness of Ecological Site Descriptions: general state and transition models and the Ecosystem Dynamics Interpretive Tool (EDIT). *Rangelands*. 38 (6), 329. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Biederman JA, Scott RL, Arnone J, Jasoni RL, Litvak ME, Moreo MT, Papuga SA, Ponce-Campos GE, Schreiner-McGraw AP, Vivoni ER (2017). Shrubland exchanges of carbon dioxide across water availability gradients warm deserts of North America. *Agricultural and Forest Meteorology*. . Status = UNDER_REVIEW; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Briske, DD, Bestelmeyer BT, Brown JR, Brunson MW, Thurow TL, and Tanaka JA (2017). Assessment of USDA NRCS Rangeland Conservation Programs: Recommendation for an Evidence-based Conservation Platform. *Ecological Applications*. 27 94. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Brown, JR and Bestelmeyer BT (2016). An introduction to the special issue: Ecological sites for landscape management. *Rangelands*. 38 (6), 311. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Browning, DM, Maynard JJ, Karl JW, and Peters DPC (2017). Breaks in MODIS time series portend vegetation change:

verification using long-term data in an arid grassland ecosystem. *Ecological Applications*. 27 1677. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1002/eap.1561

Duniway, MC, Nauman TW, Johanson JK, Green S, Miller ME, Williamson JC, and Bestelmeyer BT (2016). Generalizing ecological site concepts of the Colorado Plateau for landscape-level applications. *Rangelands*. 38 (6), 342. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Flombaum, P, Yahdjian L, and Sala OE (2017). Global-change drivers of ecosystem functioning modulated by natural variability and saturating responses. *Global Change Biology*. 23 503. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1111/gcb.13441

Franco, A, Knox MA, Andriuzzi W, Tomasel C, Sala OE, and Wall DH (2017). Nematode exclusion and recolonization in experimental soil microcosms. *Soil Biology and Biochemistry*. 108 78. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Knapp, AK, Avolio ML, Beier C, Carroll CJW, Collins SL, Dukes JS, Fraser LH, Griffin-Nolan RJ, Hoover DL, Jentsch A, Loik ME, Phillips RP, Post AK, Sala OE, Slette IJ, Yahdjian L, and Smith MD (2017). Pushing precipitation to the extremes in distributed experiments: recommendations for simulating wet and dry years. *Global Change Biology*. 23 1774. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1111/gcb.13504

Li J, Gilhooly III WP, Okin GS, and Blackwell III J (2017). Abiotic processes are insufficient for fertile island development: A 10-year artificial shrub experiment in a desert grassland. *Geophysical Research Letters*. . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1002/2016GL072068:9

McKenna, O and Sala OE (2016). Biophysical controls over concentration and depth distribution of soil organic carbon and nitrogen in desert playas. *Journal of Geophysical Research – Biogeosciences*. 121 3019. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1002/2016JG003545

Miller, JR and Bestelmeyer BT (2017). What the novel ecosystem concept provides: A reply to Kattan et al. *Restoration Ecology*. 25 488. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Moran, MS, Heilman P, Peters DPC, and Collins CH (2016). Agroecosystems research with big data and a modified scientific method using machine learning concepts. *Ecosphere*. 7 (10), . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1002/ecs2.1493

Okin, GS, Sala OE, Vivoni ER, Zhang J (2017). The Interactive Role of Wind and Water in Dryland Function: What Does the Future Hold?. *Bioscience*. . Status = UNDER_REVIEW; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Peters, DPC and Okin GS (2017). A toolkit for ecosystem ecologists in the time of big science. *Ecosystems*. 20 259. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1007/s10021-016-0072-1

Ratajczak, Z, D'Odorico P, Bestelmeyer BT, Collins SL, Isbell FI, and Nippert JB (2017). The interactive effects of press/pulse intensity and duration on regime shifts at multiple scales. *Ecological Monographs*. 87 198. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Sala, OE (2016). How Scientists Can Help End the Land-Use Conflict. *Bioscience*. 66 (11), 915. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Sayre, NF, Davis DK, Bestelmeyer B, Williamson J (2017). Rangelands: Where anthromes meet their limits. *Land*. 6 (2), 31. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.3390/land6020031

Schreiner-McGraw, AP and Vivoni ER (2017). Percolation in Arid Piedmont Watersheds: Observations from a Dense Instrument Network and Linkages to Historical Conditions. *Ecosphere*. . Status = UNDER_REVIEW; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Shackelford, N, Starzomski B, Banning N, Battaglia L, Becker A, Bellingham P, Bestelmeyer B, Catford J, Dwyer J, Dynesius M, Gilmour J, Hallett L, Hobbs R, Price J, Sasaki T, Tanner E, and Standish R (2017). Isolation predicts compositional change after discrete disturbances in a global meta study. *Ecography*. . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1111/ecog.02383

Wang, J, Monger HC, Wang X, Serena M, and Leinauer B (2016). Carbon sequestration in response to grassland-shrubland-turfgrass conversions and a test for carbonate biomineralization in desert soils, New Mexico, USA. *Soil Science Society of America*. 80 1591. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.2136/sssaj2016.03.0061

Yu, K, Okin GS, Ravi S, D'Odorico P (2016). Potential of grass invasions in desert shrublands to create novel ecosystem states under variable climate. *Ecohydrology*. 9 (8), 1496. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1002/eco.1742

Licenses

Other Conference Presentations / Papers

Other Products

Other Publications

Patent Applications

Technologies or Techniques

Thesis/Dissertations

McKenna, OP. *Desert playa wetlands: Ecological controls of their functioning and responses to climate change*. (2016). Arizona State University. Acknowledgement of Federal Support = Yes

Davanon, KA.. *The effects of urbanization on trophic interactions in a desert landscape*. (2015). New Mexico State University. Acknowledgement of Federal Support = Yes

Websites or Other Internet Sites

Asombro Institute for Science Education
http://www.asombro.org

website of our schoolyard LTER Program and associated K-12 programs and activities

EcoTrends Project
https://ecotrends.info

Long-term datasets and their metadata from 50 ecological research sites in the US along with graphing and download capabilities.

Jornada Long Term Ecological Research Program
https://jornada.nmsu.edu/lter

Website containing information about the Jornada LTER program, including projects, data and publication archives, educational materials, and employees.

USDA ARS Jornada Experimental Range Research Program
https://jornada.nmsu.edu

Website of our USDA research partner including research projects, personnel, and long-term datasets

Participants/Organizations

What individuals have worked on the project?

Name	Most Senior Project Role	Nearest Person Month Worked
Peters, Debra	PD/PI	1
Bestelmeyer, Brandon	Co PD/PI	1
Bestelmeyer, Stephanie	Co PD/PI	6
Havstad, Kris	Co PD/PI	1
Monger, Hugh	Co PD/PI	1
Archer, Steve	Co-Investigator	1
Duniway, Michael	Co-Investigator	1
Hanan, Niall	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
Tweedie, Craig	Co-Investigator	1
Vivoni, Enrique	Co-Investigator	1
Gherardi, Laureano	Postdoctoral (scholar, fellow or other postdoctoral position)	9
Levi, Matthew	Postdoctoral (scholar, fellow or other postdoctoral position)	1
Ramirez, Geovany	Postdoctoral (scholar, fellow or other postdoctoral position)	6
Brown, Joel	Other Professional	1
Browning, Dawn	Other Professional	1
Brungard, Colby	Other Professional	1

Name	Most Senior Project Role	Nearest Person Month Worked
Burruss, Nathan	Other Professional	6
Grace, Libby	Other Professional	1
Haan-Amato, Stephanie	Other Professional	1
Huang, Haitao	Other Professional	2
Pemberton, Ryan	Other Professional	1
Pietrasiak, Nicole	Other Professional	1
Somerday, Marianne	Other Professional	1
Anderson, John	Technician	12
Chepsongol, Roxanne	Technician	12
Currier, Courtney	Technician	9
Gamboa, Bernice	Technician	1
Gename, Kyle	Technician	12
Hall, Seth	Technician	12
Harrison, Charlene	Technician	6
Lenz, James	Technician	1
Ramirez, Gesuri	Technician	1
Ramsey, Kenneth	Technician	12
Schrader, Theodore	Technician	1
Yao, Jin	Staff Scientist (doctoral level)	1
Boydston, Aaron	Graduate Student (research assistant)	1
Buerdsell, Sherri	Graduate Student (research assistant)	12
Garcia, Victor	Graduate Student (research assistant)	3
Haussler, Josh	Graduate Student (research assistant)	1

Name	Most Senior Project Role	Nearest Person Month Worked
Hu, Jennifer	Graduate Student (research assistant)	12
Huang, Junxin	Graduate Student (research assistant)	6
Mason, William	Graduate Student (research assistant)	3
McKenna, Owen	Graduate Student (research assistant)	1
Naylor, Alexander	Graduate Student (research assistant)	3
Neupane, Avishesh	Graduate Student (research assistant)	3
Omari, Haneen	Graduate Student (research assistant)	3
Perez Ruiz, Eli	Graduate Student (research assistant)	12
Schreiner-McGraw, Adam	Graduate Student (research assistant)	12
Scroggs, Stacey	Graduate Student (research assistant)	2
Solgi, Mitra	Graduate Student (research assistant)	3
Wagnon, Casey	Graduate Student (research assistant)	6
Weber-Grullon, Luis	Graduate Student (research assistant)	6
Wiedenfeld, Amy	Graduate Student (research assistant)	6
Zhang, Junzhe	Graduate Student (research assistant)	12
Hallberg, Andrew	Undergraduate Student	3
Hansen, Frederick	Undergraduate Student	3
Varela, Luis	Undergraduate Student	3
Haley, Dallas	Research Experience for Undergraduates (REU) Participant	3
Vega, Miranda	Research Experience for Undergraduates (REU) Participant	3

Full details of individuals who have worked on the project:

Debra P Peters
Email: debra.peters@osec.usda.gov
Most Senior Project Role: PD/PI

Nearest Person Month Worked: 1

Contribution to the Project: Lead PI responsible for vision and project direction, reporting to NSF; and representing the ARS.

Funding Support: This project

International Collaboration: No
International Travel: No

Brandon T. Bestelmeyer
Email: brandon.bestelmeyer@ars.usda.gov
Most Senior Project Role: Co PD/PI
Nearest Person Month Worked: 1

Contribution to the Project: Co-PI responsible for state-and-transition model development; and representing the ARS.

Funding Support: 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: 6

Contribution to the Project: Director of the Asombro Institute for Science Education, the Jornada LTER schoolyard LTER program.

Funding Support: This Project

International Collaboration: No
International Travel: No

Kris M Havstad
Email: kris.havstad@ars.usda.gov
Most Senior Project Role: Co PD/PI
Nearest Person Month Worked: 1

Contribution to the Project: Co-PI leading large animal studies on the Jornada LTER; and representing the ARS.

Funding Support: This project

International Collaboration: No
International Travel: No

Hugh C Monger
Email: curtis.monger@lin.usda.gov
Most Senior Project Role: Co PD/PI
Nearest Person Month Worked: 1

Contribution to the Project: Co-PI leading geomorphology studies on the Jornada; and representing the NRCS.

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; and representing the USGS.

Funding Support: this award

International Collaboration: No
International Travel: No

Niall Hanan
Email: nhanan@nmsu.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 1

Contribution to the Project: Landscape and regional scale shrub dynamics and remote sensing

Funding Support: this award

International Collaboration: No
International Travel: No

Jeffrey E. Herrick
Email: jeff.herrick@ars.usda.gov
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; and representing the ARS.

Funding Support: this award

International Collaboration: Yes, Kenya

International Travel: No

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: No

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; and representing the ARS.

Funding Support: this award

International Collaboration: No
International Travel: No

Osvaldo 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: No

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

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: No

Laureano Gherardi
Email: lgherar1@asu.edu
Most Senior Project Role: Postdoctoral (scholar, fellow or other postdoctoral position)
Nearest Person Month Worked: 9

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: 1

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: 6

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

Colby Brungard
Email: cbrung@ad.nmsu.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 1

Contribution to the Project: Pedology and digital soil mapping

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: 1

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: 1

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

Haitao Huang
Email: haitaohuang@hotmail.com
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 2

Contribution to the Project: programming support on ecosystems models and data handling and manipulation

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: 1

Contribution to the Project: Science education specialist at Asombro

Funding Support: this award

International Collaboration: No
International Travel: No

Nicole Pietrasiak
Email: npietras@ad.nmsu.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 1

Contribution to the Project: Biotic crust function and diversity

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: 1

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

Courtney Currier
Email: Courtney.Currier@asu.edu
Most Senior Project Role: Technician
Nearest Person Month Worked: 9

Contribution to the Project: Technician working with Osvaldo Sala

Funding Support: ASU

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

James Lenz
Email: jlenz@nmsu.edu
Most Senior Project Role: Technician
Nearest Person Month Worked: 1

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: 1

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: 1

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: 1

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

Aaron Boydston
Email: aboydsto@asu.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 1

Contribution to the Project: MS graduate student working with Sala on rainfall manipulation experiment

Funding Support: this award

International Collaboration: No
International Travel: No

Sherri Buerdsell
Email: sherri@nmsu.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 12

Contribution to the Project: Graduate student working with Pietrasiak on invasive grass dynamics

Funding Support: this award

International Collaboration: No
International Travel: No

Victor Garcia
Email: vhgarcia4@miners.utep.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 3

Contribution to the Project: Summer graduate student working with Tweedie on watershed instrumentation

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: 1

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

Funding Support: this award

International Collaboration: No
International Travel: No

Jennifer Hu
Email: jenhu@nmsu.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 12

Contribution to the Project: Graduate student working with Boucheron on utilization of digital image analysis ("cow-cam") in foraging studies

Funding Support: this award

International Collaboration: No
International Travel: No

Junxin Huang
Email: hjunxin@nmsu.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 6

Contribution to the Project: Graduate student working with Peters on long term NP data analyses

Funding Support: this award

International Collaboration: No
International Travel: No

William Sean Mason
Email: xr_tron@yahoo.com
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 3

Contribution to the Project: Summer graduate student working with Hanan on UAV pilot project

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: 1

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

Funding Support: this award

International Collaboration: No
International Travel: No

Alexander Naylor
Email: aknaylor@ucla.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 3

Contribution to the Project: Summer graduate student working with Okin on ecosystem erosion model

Funding Support: this award and UCLA

International Collaboration: No
International Travel: No

Avishesh Neupane
Email: aneupane@ucla.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 3

Contribution to the Project: Summer graduate student working with Okin on wind erosion studies

Funding Support: this award and UCLA

International Collaboration: No
International Travel: No

Haneen Omari
Email: hanomari@nmsu.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 3

Contribution to the Project: Summer graduate student working with Pietrasiak on bitoic crust diversity

Funding Support: this award

International Collaboration: No
International Travel: No

Eli Perez Ruiz
Email: eperezru@asu.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 12

Contribution to the Project: Graduate student working with Vivoni on ecohydrology studies

Funding Support: this award and ASU

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: Graduate student working with Vivoni on hydrology studies

Funding Support: this award

International Collaboration: No
International Travel: No

Stacey Scroggs
Email: stscroggs@nmsu.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 2

Contribution to the Project: Graduate student working with Anderson on long-term data analysis

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: 3

Contribution to the Project: Graduate student updating the Jornada LTER web site

Funding Support: this award

International Collaboration: No
International Travel: No

Casey Wagnon
Email: wagnoncasey@yahoo.com
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 6

Contribution to the Project: Graduate student working with Schooley on small mammal dynamics and foraging behavior

Funding Support: this award and U Illinois

International Collaboration: No
International Travel: No

Luis Weber-Grullon
Email: luis.weber@asu.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 6

Contribution to the Project: Summer graduate student working with Sala on seedling dynamic with rainfall manipulation

Funding Support: this award and ASU

International Collaboration: No
International Travel: No

Amy Wiedenfeld
Email: awiedenf@asu.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 6

Contribution to the Project: Summer graduate student working with Sala on nematode responses to rainfall manipulation

Funding Support: this award and ASU

International Collaboration: No
International Travel: No

Junzhe Zhang
Email: zhangjunzhe@ucla.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 12

Contribution to the Project: Graduate student working with Okin on wind erosion studies

Funding Support: this award

International Collaboration: No
International Travel: No

Andrew Hallberg
Email: hallbe@stolaf.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 3

Contribution to the Project: Undergraduate student working with Sala on rainfall manipulation experiment

Funding Support: this award and ASU

International Collaboration: No
International Travel: No

Frederick Hansen
Email: fredh@nmsu.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 3

Contribution to the Project: Undergraduate student working with Nicole Petrasziak (NMSU) on soil crusts

Funding Support: this award

International Collaboration: No
International Travel: No

Luis Varela
Email: varelaluis1994@hotmail.com
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 3

Contribution to the Project: Undergraduate student working with Hanan on UAV pilot study

Funding Support: this award

International Collaboration: No
International Travel: No

Dallas Haley
Email: dallasliketexas@gmail.com
Most Senior Project Role: Research Experience for Undergraduates (REU) Participant
Nearest Person Month Worked: 3

Contribution to the Project: REU working with Pietrasiak on microbial crust diversity

Funding Support: this award

International Collaboration: No
International Travel: No
Year of schooling completed: Junior
Home Institution: Colorado State University
Government fiscal year(s) was this REU participant supported: 2017

Miranda Vega
Email: mirandavega10@gmail.com
Most Senior Project Role: Research Experience for Undergraduates (REU) Participant
Nearest Person Month Worked: 3

Contribution to the Project: REU working with Sala on rainfall manipulation experiment

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: 2017

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

Name	Type of Partner Organization	Location
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 plant interspace 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 plant interspace model of Schlesinger et al. (1990). The framework has also been applied to grass recovery in desertified shrublands following a 5 year wet period, and to explain long term grass dynamics and threshold behavior following drought. The application of this cross scale approach to broader scales has implications for continental scale ecology and the development of environmental observatories and networks to address broad scale 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 state and transition models for 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 long term 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 large scale variation is demanding better remote sensing technologies. Ground truth data and extensive process level studies available at the Jornada allow cross referencing with imagery from aerial, including drones and UAVs, and satellite platforms. There are few such well studied 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 to be published in 2015 and led by the Jornada Program is an example of interdisciplinarity. For example, in this issue the Jornada Program describes 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?

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. Activities at the Jornada have been leveraged extensively in other research projects that have helped to build new infrastructure, including instrumentation networks and coordinated observation sites.

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 co founder of the EcoTrends Project where the goal is to make long term 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 long term data easily used by high school students.

What is the impact on technology transfer?

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 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 Extension led 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 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 semi arid public rangelands across the western US, including Alaska.

What is the impact on society beyond science and technology?

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.

Human populations and land use patterns are changing rapidly. Jornada research provides a basic understanding of the limits to management of livestock in these systems. 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.

Our highly successful schoolyard LTER program works to increase local K 12 science literacy while also providing models of K 12 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 K 12 science literacy well beyond our region. These programs include both classroom and field investigations of basic ecological principles and the effects of past and present climate change.

Research approaches to characterize alternative states based on Jornada research have been applied throughout Mongolia and adopted by government ministries as a basis for interpreting land condition and recommending management strategies. In addition, these approaches are being applied in certain areas within Argentina.

Restoration actions carried out by the Bureau of Land Management in southwestern New Mexico now include experimental designs and monitoring procedures developed by the Jornada to test restoration effects and as a basis for adaptive management.

These types of tools are already widely applied by land managers and policymakers in the US. We have also obtained funding from USAID to develop a Land Potential Knowledge System (LandPKS), which will eventually allow these types of site specific assessments and predictions to be made globally. Finally, we are leading development of a United Nations report to increase awareness and understanding of including resilience in land potential assessments.

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.