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Accomplishments

* What are the major goals of the project?

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

The major goals of our project are:

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

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

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

4. To provide education and outreach programs across a range of scales, from local to global

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

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

Major Activities:

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

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

1. We collected field gas-exchange measurements and quantitative phenology on plants that had been sandblasted in the field (Nutrient Effects of Aeolian Transport, NEAT, experiment) and in a new wind-tunnel facility. The main hypothesis of the NEAT experiment is that aeolian transport drives grass-to-shrub transitions, and we are using this experiment and associated research to shed light on potential mechanisms. C and N measurements at the NEAT site, in soils collected 9 years after installation of the experiment, are ongoing, with a manuscript in preparation.
2. We have been experimenting with the use of Unmanned Aerial Vehicles (UAVs) for collection of field data. UAV imagery are being used to create 2-dimensional orthomosaics and 3-dimensional point clouds using the structure from motion (SFM) approach. Retrievals of vegetation structure, including cover and height have been compared to field measurements and show good fidelity. A manuscript is being prepared on UAV utilization for field based vegetation measurements.
3. We continue to document the effects of grazing intensity (low, moderate, high) and shrub removal on grass recovery in long-term plots (Stressor 2/Thresh-Ex Experiment).

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 and stochastic nature of exogenous phenomena, including El Niño and sequences of wet and dry periods that may be particularly important in vegetation dynamics, including grassland recovery, requires long-term manipulative experiments and the LTER perspective.

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 following the recent sequence of wet years (2004-2008) compared with previous wet period (1984-1988), and the long-term consequences of the multi-year pulse in precipitation.

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 conducted sampling of infiltration rates for different shrub species (mesquite, creosotebush, tarbush, mariola) and surface soil covers and related these to UAV-based elevation and vegetation species maps for use in a distributed ecohydrologic model. Ecosystem state scenarios were constructed and run through the model to evaluate the response to historical shrubland to shrubland transitions.
3. The long-term precipitation record at eastern bajada was used to parameterize a stochastic weather generator applied to downscale a set of general circulation model scenarios (16 in total) of future weather conditions. These scenarios were utilized in the distributed ecohydrologic model to understand the role of precipitation characteristics on the runoff and percolation processes (Schreiner-McGraw et al. 2018).
4. We used USGS airborne imagery at < 1 meter spatial resolution (NAIP) to map shrub canopy cover, shrub density and mean patch size across most of the Jornada Basin. We are using these data to explore processes controlling maximum shrub cover and occurrence of density dependent competitive interactions.

Novel ecosystems:The exotic grass, Lehmann's lovegrass, has not been problematic across the Chihuahuan Desert. However, higher temperatures may promote expansion of this species.

1. The exotic grass, Lehmann's lovegrass, has not been problematic across the Chihuahuan Desert. However, higher temperatures may promote expansion of this species. We are using a soil water model 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. We are also running multiple experiments to understand factors that influence establishment of this species.

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 meteorological 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. We are continuing long-term monitoring of animal consumers (rodents and lagomorphs) and their mammalian predators using live-trapping and camera-trapping to determine if population and community dynamics differ among ecosystem states.

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

1. We completed analyses of the relationships between biophysical variables 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 public education events based on JRN research.
2. Hosted the seventh 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 apps for soil and vegetation on Apple App store.

Specific Objectives:

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

Grassland to shrubland transitions:

1. To determine how soil and vegetation in the NEAT experiment (where grasses are removed each year, and shrub cover is increasing) has changed one decade after removal of grasses. We are also using UAVs to make measurements to allow quantitative understanding of patterns of change within and across geomorphic units.
2. To observe how plants and soils respond to increased aeolian transport. Our goal in this experiment is to kick-start 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. To 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 responds 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 2018-2019.

Shrubland to grassland transitions:

1. To evaluate 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 the different transition patterns, we are overlaying spatial patterns in shrub species with different explanatory data layers, such as elevation, soil texture, geomorphology, long-term precipitation, and herbivore stocking rates.
2. To determine the extent to which individual shrub species are utilizing similar or different water sources in space and time within the geomorphic template of the Tromble weir watershed, we 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 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 implications of hillslope and channel properties on the production of runoff from the watershed were evaluated yielding a set of controls on the rainfall-percolation relationship that can be extended to other regions of the eastern bajada. Evaluations of a set of vegetation change and climate change scenarios are under way to provide new understandings of the hydrologic behavior of the eastern bajada for past and future periods.

Novel Ecosystems:

1. To determine precipitation and temperature requirements for seedling establishment of the invasive Lehman's lovegrass on soils found throughout the Southwest.
2. To determine effects of herbicide treatment on Lehman's Lovegrass.
3. To investigate whether plant-soil feedbacks influence Lehman's Lovegrass competition with native grasses.
4. To evaluate the controls on growth and expansion of exotic grasses throughout the Southwest.

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

1. To develop methods for UAVs, which are validated against field data, and will help broader-scale assessment of differences across geomorphic units
2. To evaluate dynamics of rodent communities, including (a) to evaluate top-down versus bottom-up controls of consumers, (b) to determine if trophic cascades differ among ecological states, and (c) to quantify the landscape of fear for consumers and its consequence for herbivory pressure.

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

1. To broadly understand how social and ecological processes interact to determine the distribution of ecological states at the regional scale.
2. To engage directly with a community of land managers (both federal and private) to ask and answer ecological questions of interest at the regional scale using geographic information systems analysis of large, spatial datasets and monitoring data gathered by the project.

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

1. To 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. To provide support to other LTER sites interested in adopting and adapting strategies developed in cooperation with JRN, including Data Jams (Asombro Institute).
3. To 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. To increase the number, strength and diversity of partnerships through the development and strengthening of specific cooperative agreements with national and international organizations.
5. To 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. To achieve adoption of a common set of rangeland monitoring protocols based in part on JRN research.
7. To 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. To 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.

Significant Results:

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

Grassland to shrubland transitions:

1. After 20 years with no grazing in the long-term Threshold Experiment (ThreshEx), grass cover continues to increase with no sign of saturation (leveling off) following recovery from the initial, moderately grazed state. The impact of heavy grazing is still substantial, with one heavily grazed 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-yr ungrazed plots, suggesting that the effects of shrubs on grass recovery are obvious only at relatively high shrub cover.
2. Our findings indicate a negative relationship between Aeolian flux and previous growing season precipitation. Aeolian flux is considerably higher in mesquite shrubland versus grassland (Figure 1; Okin et al. 2018).

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. 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. Increased precipitation variability benefited shrubs, but their positive response was overshadowed by the negative response of grasses until year 6.
3. Our analyses of long-term NPP at the 15 locations showed that perennial grass response during the multi-year wet period (2004-2008) have been maintained through time even though precipitation has been temporally variable.

Shrubland to shrubland transitions:

1. Results from modeling the six-year record of simultaneous water balance and flux measurements in the Tromble Weir watershed yielded confidence in the model capability to reproduce hydrologic and energy conditions.(Schreiner-McGraw and Vivoni, 2018).
2. Modeling scenarios were utilized to explore the role played by hillslope and channel infiltration conditions on the process of deep percolation (or transmission losses), identified previously from the long-term observations at the Tromble Weir. The the anticipated effect of changing the saturated hydraulic conductivity in hillslopes (K_{hill}) or channels (K_{chan}) on the proportion of rainfall that becomes percolation losses (P/R) was explored.
3. Deep percolation (mm/month) over a century (1915-2016) was estimated for arid first-order watersheds commonly found in the Jornada Basin. 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.
4. Maximum shrub canopy cover across the Basin appears to be ~40% at 1 hectare scales, with a weak but statistically significant unimodal relationship between landform type (soil water holding capacity and clay content) and maximum shrub cover, and detection of self-thinning (i.e. shrub-shrub competition) in landscapes with shrub cover > 35%.

Novel Ecosystems:

1. Lehmann lovegrass plants were treated with herbicide in October 2017 and regrowth was treated in October 2018. To date there are no significant differences in native plant cover between treatments with and without herbicide, and no recruitment of new black grama plants.
2. An experiment tested in the influence of precipitation on black grama and Lehman lovegrass percent cover. Black grama percent cover decreased under a decreased precipitation treatment ($p=0.03$), but was not significantly different among years. Lehmann lovegrass cover was not significantly different between irrigated and control treatments, but did differ between years.
3. To evaluate potential plant-soil feedbacks, soil samples were used in a replacement series experimental design integrated into a two-phase plant-soil feedback experimental approach. Results also indicate that competition alone plays a greater role in grama-

lovegrass dynamics than do plant-soil feedbacks, with lovegrass being a far superior competitor than blue grama.

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.
2. 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 (Figure 2; Schooley et al. 2018). Granivores were mostly core species responding postively to ANPP with a lag of up to 1 yr, whereas folivores included transient species that responded to lagged precipitation at broader spatial scales via spillover dynamics (Schooley et al. 2018).

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

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 (Levi 2016).

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

1. A total of 25,156 K-12 students, 712 teachers, and 878 other adults participated in 8 field trips, 973 one-hour classroom/schoolyard lessons, 3 teacher workshops, and 20 family events, where they learned about JRN research by participating in inquiry-based activities. Six graduate students 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 2018. In total, 476 middle school students from southern New Mexico participated. The top projects from each school (49 projects total, 88 students) participated in the final competition from April 24-26. JRN staff also assisted other LTER educators, who subsequently hosted 2018 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 was successfully developed and released via the Google Play and Apple Ap Stores.

7. The JRN-LTER provided graduate fellowships this year for research at the Jornada to 7 students, including two 12-month fellowships and 5 summer fellowships. Our annual Desert Ecology Short-Course (July 2018) was attended by these students and an additional 17 graduate students from NMSU and neighboring universities in New Mexico, Texas and Arizona.
8. We supported two undergraduate REU students in Summer 2018 and four additional undergraduate research fellows participated in Jornada research in 2018, including attending the annual Desert Ecology Short-Course.

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 Nutrient and Ecosystem Impacts of Aeolian Transport (NEAT) reanalysis. Another is in preparation that outlines the analysis of NPP results from a remote sensing perspective. Four UCLA students (Avishesh Neupane, Junzhe Zhang, Michael Fischella, and Shereen Nadoum) 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.
2. Perennial grass recovery in degraded shrublands has historically been thought to be nearly impossible. Recent results from our long-term monitoring plots shows that perennial grass response in degraded shrublands can occur during wet periods that consist of very high pulses of precipitation in individual years (2006, 2008) compared with little sustained grass response in a wet period with similarly high rainfall every year (1984-1988).
3. Using a transdisciplinary modeling approach, we developed an index of grass recovery that is based on soil properties and initial grass biomass but is not specific to an ecosystem type (Figure 3; Peters et al. 2018)

Shrubland to shrubland transitions:

1. Our view of the eastern bajada has changed from a static perception driven by knowledge of 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 was tested under different vegetation states, for different hillslope and channel infiltrations conditions and for a set of climate change scenarios. The vegetation scenarios will be used to determine the effect of dynamically changing landscapes on water yield and groundwater recharge from first-order watersheds.
3. A new shrub canopy cover, density and patch size map has been created and will be made available following publication of the associated journal article (Ji et al., in review) via the JRN website.

Novel Ecosystems:

1. Our preliminary results provide baseline data about the challenges in controlling non-native Lehman's lovegrass, which will guide future research efforts.

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 are improving 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 consumers such as rodents.

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

1. We held a stakeholder meeting with representatives of land management agencies (Restore New Mexico program) and producers to review long-term (5-10 yr) responses of perennial grasses to shrub management practices based on new analyses. These results are being used to develop guidelines for subsequent shrub management applications in the region.

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

1. Our k-12 education program, led by the Asombro Institute for Science Education, has adapted its efforts over the years in order to continue providing experiential learning despite shifts in local, state, and federal policies, and education trends (Figure 4;

Bestelmeyer S et al. 2018). During the 2017-2018 performance period 25,156 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 interpreting and communicating about long-term datasets through the Data Jam. Seventy-one percent of anonymous survey respondents (n=45) said Data Jam participation increased their interest in college studies and/or careers in science.
3. We assisted the government of Mongolia in producing a revised catalog of state-and-transitions models based on concepts developed at JRN. These models are being used as the basis for interpreting national monitoring data and production a national report on Mongolian rangeland conditions.

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

1. A total of 25,156 K12 students have been trained with increased appreciation of arid land ecology, particularly the Chihuahuan Desert and current research being conducted by LTER scientists.
2. More than 450 students have gained skills both interpreting and then communicating large, longterm, 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.
4. The JRN-LTER provided graduate fellowships this year for research at the Jornada to 7 students, including two 12-month fellowships and 5 summer fellowships. Our annual Desert Ecology Short-Course (July 2018) was attended by these students and an additional 17 graduate students from NMSU and neighboring universities in New Mexico, Texas and Arizona.
5. We supported two undergraduate REU students in Summer 2018 and four additional undergraduate research fellows participated in Jornada research in 2018, including attending the annual Desert Ecology Short-Course.
6. We assisted the government of Mongolia in producing a revised catalog of state-and-transitions models based on concepts developed at JRN. These models are being used as the basis for interpreting national monitoring data and production a national report on Mongolian rangeland conditions.

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

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

Grassland to shrubland transitions:

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

Shrubland to grassland transitions:

1. The new results have been communicated through scientific meetings and publications in high impact journals.

Shrubland to shrubland transitions:

1. Results have been disseminated to communities in the geological and ecological sciences, with participation in cross-site shrubland comparisons (Biederman et al, 2018) and collaborations with new groups in Australia (Rossi et al., 2018) and in Israel (Ben Gurion University). A manuscript is in review (Ji et al., Ecosphere) describing the new shrub maps for the JRN study site and analysis of resource-related maximum canopy cover and detection of shrub-shrub competition in high-cover locations.

Novel Ecosystems:

1. No results have been disseminated. Results are preliminary.

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

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

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

1. Results have been disseminated via meetings with land management agencies and stakeholders

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

1. A total of 25,156 K12 students have been trained with increased appreciation of arid land ecology, particularly the Chihuahuan Desert and current research being conducted by LTER scientists.
2. More than 450 students have gained skills both interpreting and then communicating large, longterm, 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.

* 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 will be continuing field and experimental manipulations of aeolian transport and its effects on plant physiology and phenology

2. We will continue calibration of UAV-derived measurements against field measurements on different geomorphic units.

Shrubland to grassland transitions:

1. We are continuing our long-term ANPP study, and will focus on long-term recovery and persistence of grasses since 2011 to test hypotheses about factors controlling grass persistence in different types of shrublands. 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 (UAVs) 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.
3. 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.
4. We will use time series data from our eddy covariance tower, robotic tram system for measuring spectral reflectance, micrometeorological network, phenocams, and phenophase monitoring to explore the biophysical and species-specific controls of land-atmosphere fluxes.
5. We will capitalize on the phenological differences between the major shrub types and long-term medium resolution (Landsat, 30 m) satellite data to associate species labels with shrub canopy cover, density and size estimates. This will provide more detailed information on shrub distributions across the site and cover-density-size relationship with soils, landforms and management history.

Novel Ecosystems:

1. We plan on running the Ecotone model (A mixed lifeform individual plant-based gap dynamics model, see Peters 2002) to examine controls on the growth and expansion of exotic grasses at the Jornada and throughout the Southwest.
2. Plots from the herbicide / reseeding study will be monitored a final time during peak growth next August. Data analysis and writing will commence soon after, with the possibility of a peer-reviewed paper to be submitted in 2019.

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

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

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

1. We will conduct further 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 scale.

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 public education events, and the 2018/19 Desert Data Jam competition. We will continue to involve JRN graduate students in developing and implementing new K-12 programs.

Supporting Files (Figures 1-4)

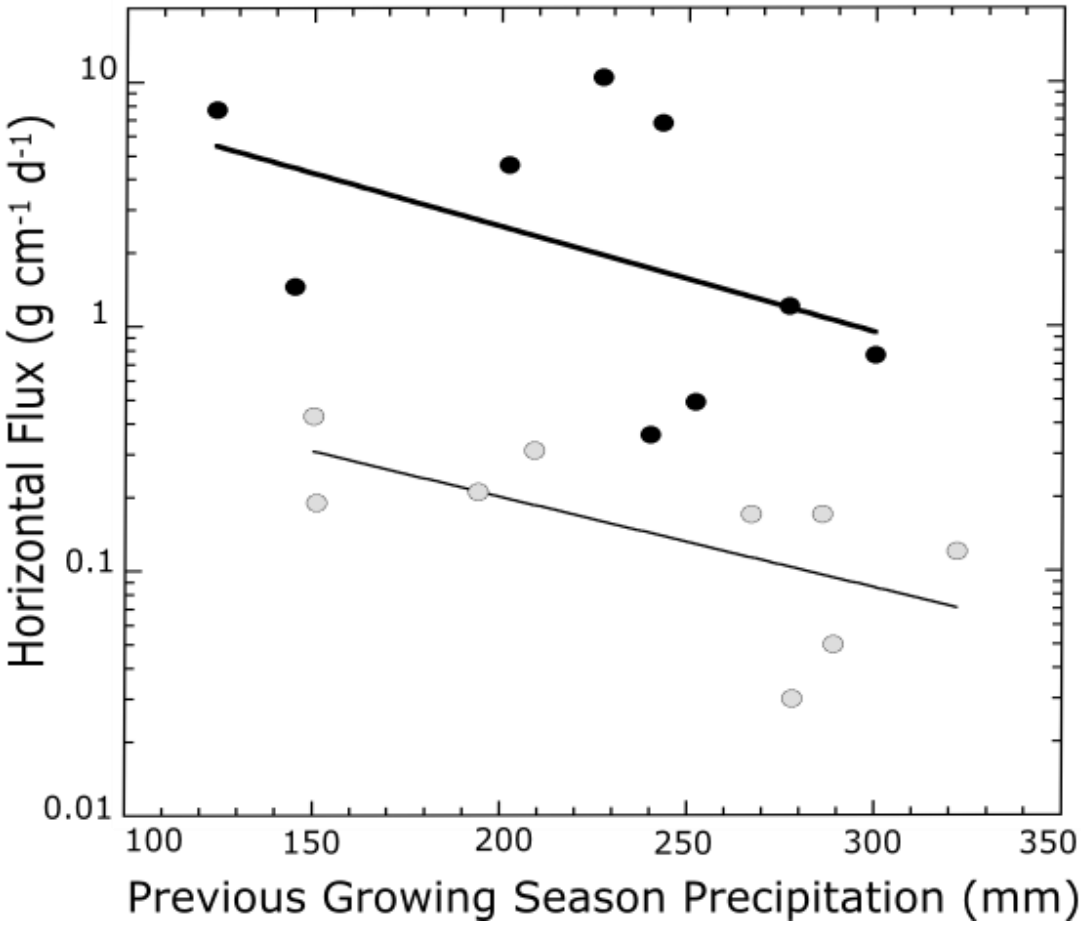

Figure 1. The log-linear relations between horizontal aeolian flux and precipitation in the previous growing season for mesquite shrubland (black) and grassland (gray). A greater length of connected pathways for a mesquite shrubland produces nearly an order of magnitude greater aeolian transport than a grassland on similar soils ($p<0.01$) (Okin et al. 2018)

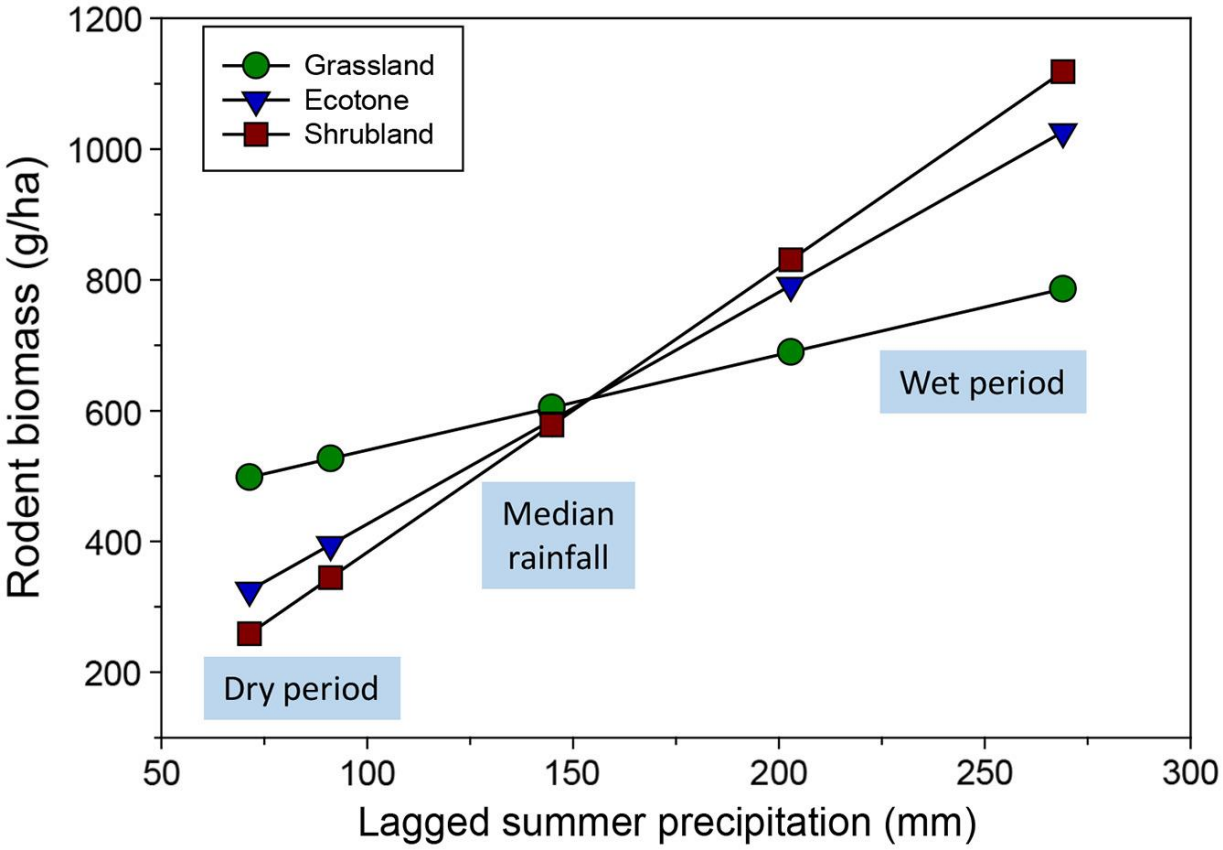

Figure 2. Interactive effects of precipitation (1-yr lag) and shrub encroachment on total rodent biomass at Jornada Basin Long Term Ecological Research site. Following years with typical summer precipitation, rodent biomass is similar for all three states. Following dry years, predicted biomass is greater on grasslands than on shrubbier sites. Following et years, predicted biomass is greater on shrubbier sites. (Schooley et al 2018)

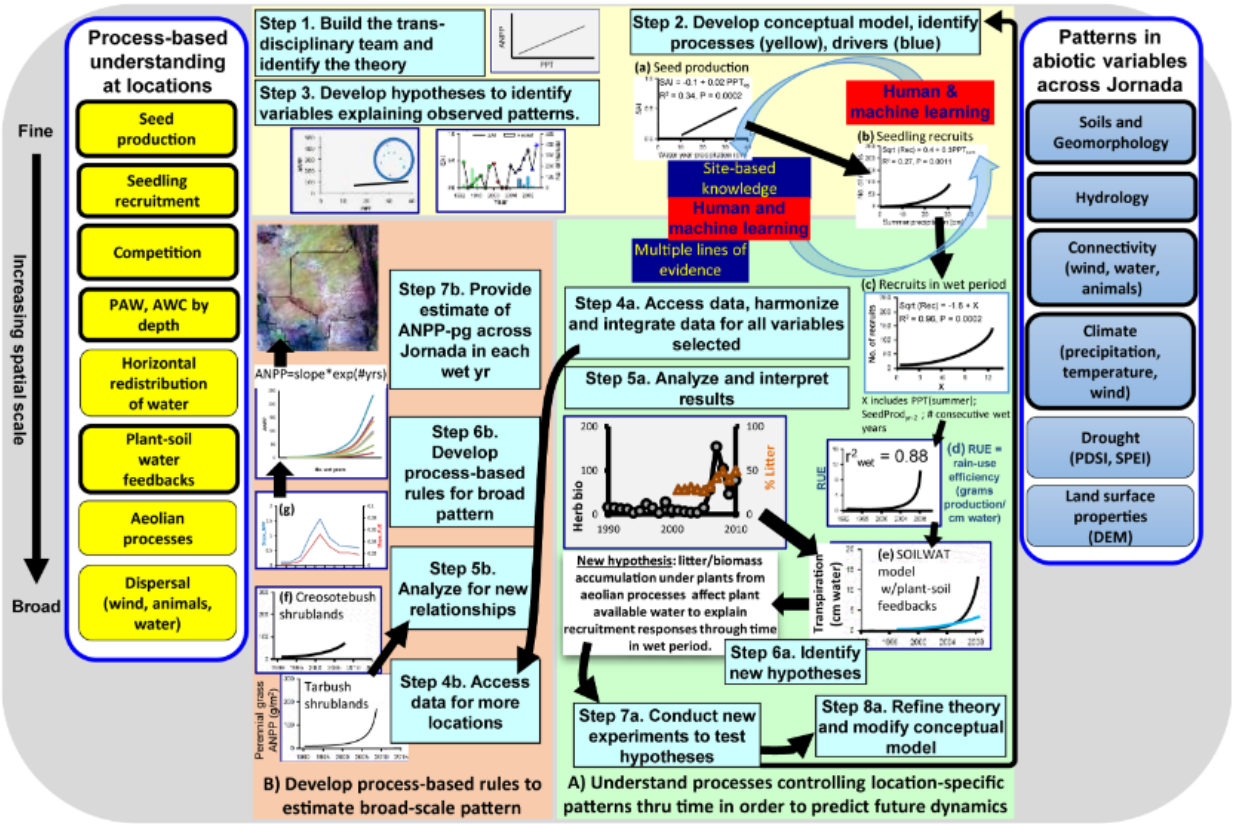

Figure 3. An example of our transdisciplinary data-model integration approach. In this example, we used a process-based understanding to develop relationships between precipitation and ANPP during wet and dry periods in different ecosystem types. We used this relationship to develop an index of grass recovery that is based on soil properties and initial grass biomass but is not specific to an ecosystem type. This index of grass recovery can be tested at other dryland locations (Peters et al 2018).

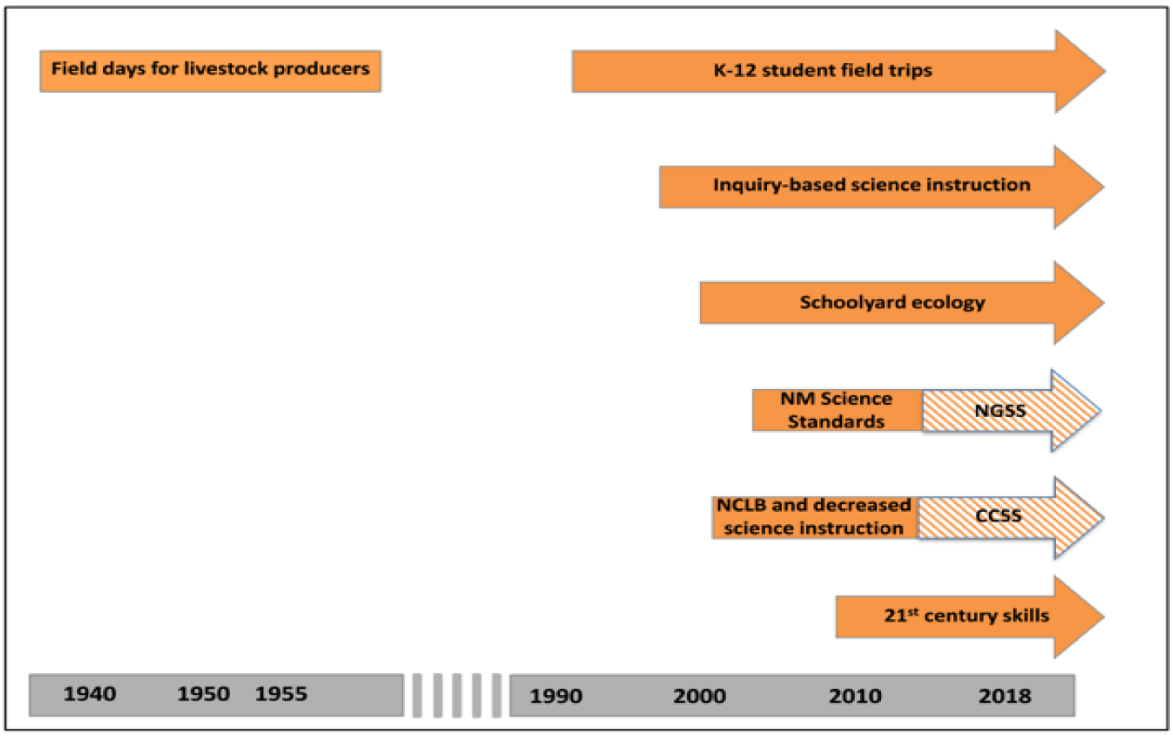

Figure 4. Our k-12 education program, led by the Asombro Institute for Science Education, has adapted its efforts over the years in order to continue providing experiential learning despite shifts in local, state, and federal policies, and education trends. In more recent years, this approach has included schoolyard ecology to accommodate budget and time constraints of schools and teachers, aligning our programs to the new science education standards, integrating science learning into language arts and math curriculum to satisfy the requirements No Child Left Behind, and incorporating twenty-first century learning skills (critical thinking, communication, collaboration, and creativity) into activities. (S. Bestelmeyer et al. 2018)

PRODUCTS

Journals or Juried Conference Papers

- Apodaca, M., McInerney J, Sala OE, Katinas L, and Crisci J (2018). A Concept Map of Evolutionary Biology to Promote Meaningful Learning in Biology. American Biology Teacher. *American Biology Teacher*. . Status = AWAITING_PUBLICATION; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; OTHER:
- Bestelmeyer, BT., Peters DPC,. Archer SR, Browning DM, Okin GS, Schooley RL, and Webb NP (2018). The grassland-shrubland regime shift in the southwestern United States: misconceptions and their implications for management. *BioScience*. 68 678. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1093/biosci/biy065
- Bestelmeyer, S, Grace E, Haan-Amato S, Pemberton R, and Havstad K (2018). Broadening the impact of k–12 science education collaborations in a shifting education landscape. *BioScience*. 68 706. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1093/biosci/biy088
- 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*. 249 407. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1016/j.agrformet.2017.11.005
- Browning DM, Crimmins TM, James DK, Spiegal S, Levi MR, Anderson JP, and Peters DPC (2018). Synchronous species responses reveal phenological guilds: implications for management. *Ecosphere*. 9 e02395. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1002/ecs2.2395
- Collins, SL (2018). Connectivity and scale in dryland ecosystems. *BioScience*. 649 . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1093/biosci/biy087
- Dornelas M., and BioTIME consortium (200+ authors including D. Lightfoot and R. Schooley (2018). BioTIME: a database of biodiversity time series for the Anthropocene. *Global Ecology and Biogeography*. 27 760. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1111/geb.12729
- Duniway, MC., Petrie MD, Peters DPC, Anderson JP, Crossland K, and Herrick JE (2018). Soil water dynamics at 15 locations distributed across a desert landscape: insights from a 27-yr dataset. *Ecosphere 9: article e02335. doi:10.1002/ecs2.2335.*. 9 e02335. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1002/ecs2.2335
- Forster M., Bestelmeyer S., Baez-Rodriguez N, Berkowitz A, Caplan B, Esposito, R., Grace E., and McGee S (2018). Data Jams: promoting data literacy and science engagement while encouraging creativity. *The Science Teacher*. 86 48. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; ISSN: 0036-8555
- Koerner, SE, Smith MD, Burkepile DE, Hanan NP, Avolio ML, Collins SL, Knapp AK, Lemoine NP, Forrestel EJ, Eby S, Thompson DI , Aguado-Santacruz G, Anderson JP, Anderson M, Angassa A, Bagchi S, Bakker ES, Bastin G,. Baur LE, Beard KH, Beever EA,. Bohlen PJ, Boughton EH, Canestro D, Cesa A, Chaneton E, Cheng J, D'Antonio CM, Deleglise C, Dembélé

F, Dorrough J, Eldridge D, Fernandez-Going B, Fernández-Lugo S, Fraser LH, Freedman B, Salgado GG,. Goheen JR, Guo L, Husheer S,. Karembé M, Knops JMH, Kraaij T, Kulmatiski A, Kytöviita M, Lezama F, Loucougaray G, Loydi A, Milchunas DG, Milton S, Morgan JW, Moxham C, Nehring KC, Olff H, Palmer TM, Rebollo S, Riginos C, Risch AC, Rueda M, Sankaran M, Sasaki T, Schoenecker K, Schultz NL, Schütz M, Schwabe A, Siebert D, Smit X, Stahlheber KA, Storm C, Strong DJ, Su J, Tiruvaimozhi YV, Tyler C, Val J, Vandegehuchte ML,Veblen KE, Vermeire LT, Ward D, Wu J, Young TP, Yu Q, Zelikova TJ (2018). Change in dominance determines herbivore effects on plant biodiversity.. *Nature Ecology and Evolution*. 2 1925. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1038/s41559-018-0696-y

- McKenna, OP and. Sala OE (2018). Groundwater recharge in desert playas: current rates and future effects of climate change. *Environmental Research Letters*. 13 014025. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1088/1748-9326/aa9eb6
- McKenna, OP., and Sala OE (2018). Playa-wetlands effects on dryland biogeochemistry: space and time interactions. *Journal of Geophysical Research - Biogeosciences*. 123 1879. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1029/2017JG004176
- Munson, SM, Reed SC, Peñuelas J, McDowell NG, and Sala OE (2018). Ecosystem thresholds, tipping points, and critical transitions. *New Phytologist*. 218 1315. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1111/nph.15145
- Okin, GS, Sala OE, Vivoni ER, Zhang J (2017). The Interactive Role of Wind and Water in Functioning of Drylands: What Does the Future Hold?. *Bioscience*. 68 670. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1093/biosci/biy067
- Peters, DPC., Burruss DN, Rodriguez L, McVey DS, Elias EH, Pelzel-McCluskey AM, Derner JD, Schrader TS, Yao J, Pauszek SJ, Lombard J, Archer SR, Bestelmeyer BT, Browning DM, Brungard CW, Hatfield JL, Hanan NP, Herrick JE, Okin GS, Sala OE, Savoy H, and Vivoni ER (2018). An integrated view of complex landscapes: a big data-model integration approach to trans-disciplinary science. *Bioscience*. 68 (653), 653. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1093/biosci/biy069
- Read QD, Grady JM, Zarnetske PL, Record S, Baiser B, Belmaker J, Tuanmu M-N, Strecker A, Beaudrot L, and Thibault KM (2018). Among-species overlap in rodent body size distributions predicts species richness along a temperature gradient. *Ecography*. 41 1. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1111/ecog.03641
- Ross, CW, Prihodko L, Anchang J, Kumar S, Ji W, and Hanan NP (2018). HYSOGs250m, global gridded hydrologic soil groups for curve-number-based run off modeling. *Scientific Data*. 5 180091. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1038/sdata.2018.91
- Rossi MJ., Ares JO, Jobbágy EG, Vivoni ER, Vervoort RW, Schreiner-McGraw AP, and Saco PM (2018). Shrub encroachment, productivity pulses, and core-transient dynamics of Chihuahuan Desert rodents. *Ecosphere*. 9 e02330. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1002/ecs2.2330.
- Schooley, RL, Bestelmeyer BT, and Campanella A (2018). Shrub encroachment, productivity pulses, and core-transient dynamics of Chihuahuan Desert rodents.. *Ecosphere*. 9 e02330.

Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1002/ecs2.2330

- Schreiner-McGraw, AP and Vivoni ER (2017). Percolation observations in an arid piedmont watershed and linkages to historical conditions in the Chihuahuan Desert. *Ecosphere*. 8 e02000. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1002/ecs2.2000
- Schreiner-McGraw, AP, Ajami, H., and Vivoni, ER (2018). Extreme weather events and transmission losses in arid streams. *Geophysical Research Letters*. . Status = UNDER_REVIEW; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes
- Schreiner-McGraw, AP, and Vivoni ER (2018). On the sensitivity of hillslope runoff and channel transmission losses in arid piedmont slopes. *Water Resources Research*. 54 4498. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1029/2018WR022842
- Shriver, RK (2017). Rainfall variability and fine-scale life history tradeoffs help drive niche partitioning in a desert annual plant community. *Ecology Letters*. 20 1231. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1111/ele.12818
- Svejcar LN, Bestelmeyer BT, James DK, and Peters DPC (2018). The effect of small mammal exclusion on grassland recovery from disturbance in the Chihuahuan Desert. *Journal of Arid Environments*. . Status = UNDER_REVIEW; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes
- Wenjie J, Hanan NP, Browning DM, Monger HC, Peters DPC, Bestelmeyer BT, Archer SR, Ross CW, Lind BM, Anchang J, Kumar SS, and Prihodko L (2018). Constraints on shrubcover and shrub-shrub competition in a U.S. Southwest desert. *Ecosphere*. . Status = UNDER_REVIEW; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes
- Wilcox, KR Tredennick AT, Koerner SE, Grman E, Hallett LM, Avolio ML, Pierre KJL, Houseman JR, Isbell F, Johnson DS, Alatalo JM, Baldwin AH, Bork EW, Boughton EH,. Bowman WD, Britton AJ, Cahill Jr. JF, Collins SL, Du G, Eskelinen A, Gough L, Jentsch A , Kern C, Klanderud K, Knapp AK, Kreyling J, Luo Y, McLaren JR, Megonigal P, Onipchenko V, Prevéy J, Price JN, Robinson CH, Sala OE, Smith MD, Soudzilovskaia NA, Souza L, Tilman D, White SR, Xu Z, Yahdjian L, Yu Q, Zhang P, and Zhang Y (2017). Asynchrony among local communities stabilises ecosystem function of metacommunities. *Ecology Letters*. 20 1534. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1111/ele.12861

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

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
Hanan, Niall	Co PD/PI	1
Monger, Hugh	Co PD/PI	1
Archer, Steve	Co-Investigator	1
Duniway, Michael	Co-Investigator	1
Herrick, Jeffrey	Co-Investigator	1
Okin, Gregory	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)	2
Brown, Joel	Other Professional	1
Browning, Dawn	Other Professional	1
Brungard, Colby	Other Professional	1
Burruss, Nathan	Other Professional	6
Grace, Libby	Other Professional	1
Haan-Amato, Stephanie	Other Professional	1
Huang, Haitao	Other Professional	6
James, Darren	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	12
Gamboa, Bernice	Technician	1
Gename, Kyle	Technician	12
Hall, Seth	Technician	12
Harrison, Charlene	Technician	6

Name	Most Senior Project Role	Nearest Person Month Worked
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
Hu, Jennifer	Graduate Student (research assistant)	12
Huang, Junxin	Graduate Student (research assistant)	6
Jordan, Sam	Graduate Student (research assistant)	12
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
Ratner, Yonatan	Graduate Student (research assistant)	3
Rockwell, Elizabeth	Graduate Student (research assistant)	6
Schreiner-McGraw, Adam	Graduate Student (research assistant)	12
Scroggs, Stacey	Graduate Student (research assistant)	2
Solgi, Mitra	Graduate Student (research assistant)	3
Teichert, Zebediah	Graduate Student (research assistant)	6
Wagner, Svenja	Graduate Student (research assistant)	12
Wagnon, Casey	Graduate Student (research assistant)	8
Weber-Grullon, Luis	Graduate Student (research assistant)	12
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: deb.peters@ars.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 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 program

Funding Support: This Project

International Collaboration: No
International Travel: No

Niall P Hanan
Email: nhanan@nmsu.edu

Most Senior Project Role: Co PD/PI
Nearest Person Month Worked: 1

Contribution to the Project: Co-PI working on landscape and regional scale shrub dynamics and remote sensing

Funding Support: this award

International Collaboration: No
International Travel: No

Hugh C Monger
Email: cmonger@nmsu.edu
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 respresenting 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

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

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: 2

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: 6

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

Funding Support: this award

International Collaboration: No
International Travel: No

Darren James
Email: Darren.James@ars.usda.gov
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 2

Contribution to the Project: Assist with data management

Funding Support: This award and ARS

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: 12

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

Sam Jordan
Email: sam.jordan@asu.edu

Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 12

Contribution to the Project: graduate student for Osvaldo Sala

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

Yonatan Ratner
Email: yratner@asu.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 3

Contribution to the Project: graduate student for Enrique Vivoni

Funding Support: this award and other grant sources

International Collaboration: No
International Travel: No

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

Contribution to the Project: graduate student for Enrique Vivoni

Funding Support: this award and other grant sources

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

Zebediah Teichert
Email: zteicher@asu.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 6

Contribution to the Project: Grad student for Enrique Vivoni

Funding Support: this award

International Collaboration: No
International Travel: No

Svenja Wagner
Email: skwagne1@asu.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 12

Contribution to the Project: Graduate student for Osvaldo Sala

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: 8

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: 12

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: 2018

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: 2018

What other organizations have been involved as partners?

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

Full details of organizations that have been involved as partners:

Arizona State University

Organization Type: Academic Institution
Organization Location: Tempe, AZ

Partner's Contribution to the Project:
Financial support
In-Kind Support
Facilities
Collaborative Research
Personnel Exchanges

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

Asombro Institute for Science Education

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

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

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

Bureau of Land Management

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

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

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

Center for Applied Remote Sensing in Agriculture, Meteorolog

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

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

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

Institute for Natural Resource Analysis and Management

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

Partner's Contribution to the Project:
Facilities

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

US Geological Survey

Organization Type: Other Organizations (foreign or domestic)
Organization Location: Moab, UT

Partner's Contribution to the Project:
Financial support
In-Kind Support
Facilities
Collaborative Research
Personnel Exchanges

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

USDA ARS, Jornada Experimental Range

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

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

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

USDA NRCS

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

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

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

University of Arizona

Organization Type: Academic Institution
Organization Location: Tucson, AZ

Partner's Contribution to the Project:
Financial support
In-Kind Support
Facilities
Collaborative Research
Personnel Exchanges

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

University of California-Berkeley

Organization Type: Academic Institution
Organization Location: Berkeley, CA

Partner's Contribution to the Project:
Financial support
In-Kind Support
Facilities
Collaborative Research
Personnel Exchanges

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

University of California-Los Angeles

Organization Type: Academic Institution
Organization Location: Los Angeles

Partner's Contribution to the Project:
Financial support
In-Kind Support
Facilities
Collaborative Research
Personnel Exchanges

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

University of Illinois

Organization Type: Academic Institution
Organization Location: Urbana-Champaign

Partner's Contribution to the Project:
Financial support
In-Kind Support
Facilities
Collaborative Research
Personnel Exchanges

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

University of Texas-El Paso

Organization Type: Academic Institution
Organization Location: El Paso, TX

Partner's Contribution to the Project:
Financial support
In-Kind Support
Facilities
Collaborative Research
Personnel Exchanges

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

What other collaborators or contacts have been involved?

Nothing to report

Impacts

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

The original resource redistribution framework for desertification that was articulated by Jornada researchers in the late 1980s has been a primary conceptual model for ecosystems research in arid and semiarid systems globally. The concept that shrub dominance in former grasslands can exacerbate patchiness in soil resources and provide a positive feedback to continued shrub dominance has stimulated research at the Jornada and other sites globally. More recently, our landscape linkages framework expands on the 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 (2015), BioScience 2018) and Ecosphere (2018), led by the Jornada Program, provide examples of inter-disciplinary approaches and solutions to understanding and managing arid lands. Papers in these special issues describe 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.