JRN-8: Annual Report (Year 1)

Award Number: 2425143

Project Title: LTER: Advancing ecological understanding of drylands through integrated research at the Jornada Basin (JRN-8)

Project/Grant Period: 03/15/2025 - 02/28/2031

Reporting Period: 03/15/2025 - 02/28/2026

ACCOMPLISHMENTS

What are the major goals of the project?

Since its inception, the Jornada Basin LTER (JRN) has expanded knowledge of ecosystem dynamics in drylands. Historically, research at JRN focused on the shift from perennial grassland to shrublands occurring in the Southwest and globally, capitalizing on data extending nearly 110 years from the USDA Jornada Experimental Range. More recently, JRN has elucidated how cross-scale interactions and feedbacks govern several types of state change, including grass recovery. In this phase of the JRN LTER program, we build on and expand JRN's long-term field-based, conceptual, and theoretical research.

Obj. 1. understand how changing precipitation, atmospheric humidity, temperature, and land management control ecosystem state change in drylands.

Obj. 2. assess how carbon and nutrient cycling, and nutrient co-limitations, respond to and control dryland vegetation states.

Obj. 3. quantify how spatial connectivity with respect to wind and water transport can reinforce or reverse ecosystem state change.

Obj. 4. characterize the biotic interactions underlying vegetation state change, including demographic processes, plant-microbe interactions, and trophic feedbacks.

In JRN-8 we will extend our research on key dryland processes relating to climate and management disturbances, the processes controlling primary production, carbon and inorganic nutrient cycles, population and trophic interactions with state change, and the critical role of connectivity to wind and water driving state change. JRN-8 will resolve key questions towards our overarching goal to identify the mechanisms and consequences of abrupt and persistent state changes in drylands, and advance our ability to predict dryland futures under global change. Advances in understanding state change in drylands will provide new insight into the occurrence of abrupt state changes, tipping points, and hysteresis in other ecological systems.

We will expand our award-winning education and outreach programs, with a particular focus on

our programs for K-12 students, teachers, and community members, and increased engagement with undergraduate students, graduate students, new investigators, and collaborators. Through a unique partnership, JRN science education programs reach tens of thousands of students each year. JRN also has a long history of research co-production with land managers in the Southwest and internationally, informing land health monitoring and decision making through integration of dryland state change frameworks into land management programs. These broader impacts to dryland management will expand in JRN-8, with dryland modeling tools providing new opportunities for JRN research to inform earth system models for prediction and management of dryland responses to global change.

What was accomplished under these goals?

Major Activities

Obj. 1: to understand how changing precipitation, atmospheric humidity, temperature, and land management control ecosystem state change in drylands

A. Weather and soil moisture monitoring

To complement several multi-decadal meteorological and soil profile data streams collected in the Jornada Basin, JRN and affiliated programs have deployed over 100 new automated stations throughout the Jornada Basin over the past decade and a half. These stations observe the changing climate and physical environment of the Basin, at a broad spatial scale and high temporal resolution. In the past year JRN has maintained the infrastructure, quality-assured the data and published updated datasets from 65 of these stations.

B. Net primary production monitoring

Long-term monitoring of vegetation communities is critical to this research objective, and JRN has continued annual monitoring of species-specific plant aboveground net primary production (ANPP) at 15 sites across the Jornada Basin. These sites are paired with the weather stations above, and field and derived ANPP data for all have been published through 2025. In late 2025 a working group formed to consider new methods for estimating species-level plant cover at these sites, compatible with the NutNet cover protocol and including cover classes for biological soil crusts. Long-term observations of biocrust cover, in coordination with complementary observations of biocrust productivity and associated physical and biogeochemical processes, will help quantify their contribution to the structure and function of dryland ecosystems.

C. Climate experiments

In the context of understanding how biocrust impacts rainfall pulse responses we conducted experiments on a variety of microbial isolates from biocrust to determine inherent adaptations to rainfall pulse frequency and their genomic basis. We also expanded our global change

experiments, focusing on long-term rainfall manipulations and the addition of a factorial rainfall and atmospheric vapor pressure deficit (VPD) experiment to study the interaction between changing rainfall amount and atmospheric humidity.

Obj. 2: to assess how carbon and nutrient cycling, and nutrient co-limitations, respond to and control dryland vegetation states

A. Eddy covariance flux network

JRN researchers maintained automated soil CO_2 systems and microclimate sensors paired with eddy covariance towers to quantify gas exchange and link moisture and temperature conditions to plant microsites and bare interspaces. We maintained six eddy covariance systems, coordinated site-wide instrument calibrations, and coordinated vegetation measurements within tower footprints for planned model integration.

B. Soil autochamber measurements

Analysis of the soil autochamber experiments focused on testing the islands of fertility hypothesis, revealing that CO_2 respiration rates are higher at mesquite canopy driplines than in interspaces with biocrusts. Event-based analysis indicated that time since previous precipitation explained more variation in CO_2 exchange than precipitation event size at both microsites.

Microbial community contributions to carbon and nutrient cycling

We performed soil metabolomic analysis on a phosphorus addition experiment to examine microbial photosynthesis contributions to organic carbon stocks, extended to arid lands through meta-analysis. A three-year microbiome assessment examined how soil microbes associated with perennial grasses versus plant interspaces respond to shifts in water and nutrient regimes. Experiments continued on microbial chemical communication governing nitrogen fixation in biocrusts, and researchers conducted a new experiment assessing metal limitation of nitrogen fixation.

Obj. 3: to quantify how spatial connectivity with respect to wind and water transport can reinforce or reverse ecosystem state change

Hydrological connectivity

In support of the hydrological connectivity theme, several experimental and monitoring improvements were made, including: 1) upgrade of Tromble Weir instrumentation: (a) instrument, solar panel and data logger upgrades, (b) improved cellular communication, and (c) removal of non-functional sensors; 2) installation of new instruments: (a) three Cosmic-Ray Neutron Soil Moisture sensors, (b) three LICOR 720 Water and Carbon Nodes (2-D eddy covariance method), (c) three time-lapse cameras, and (d) ancillary meteorological

measurements. These installations at Tromble Weir include new mid-slope and flat sites along the Eastern Bajada; and, 3) data processing and quality control up to summer 2025 for Tromble Weir datasets.

Aeolian connectivity

The TRIGGER study has continued as planned, with vegetation measurements every two years. The NEAT experiment continues to run, with regular measurement of vegetation cover and planned UAV-derived estimates of plant cover, height, and gap size. Earlier biocrust inoculations on NEAT Block 1 appear to have failed, thus not allowing us to address the interactions between biocrust and aeolian processes as we had originally planned. However, on NEAT Block 3, we have observed natural establishment of biocrust in some plots which we will quantify this year to test the hypothesis that more biocrust establishes in areas with greater protection from aeolian transport (i.e., areas with higher grass cover and smaller erodible gaps).

Obj. 4: to characterize the biotic interactions underlying vegetation state change, including demographic processes, plant-microbe interactions, and trophic feedbacks.

The Ecotone study, bird and bat interactions

We continued long-term sampling of rodents, lagomorphs, and canid predators to examine trophic interactions and feedbacks during grass-shrub state transitions. We also collected data on bat activity and species diversity using acoustic detectors deployed since October 2024 near the Ecotone study sites. We sampled arthropod communities at these sites to compare with those found in bat guano and to serve as a baseline for upcoming acoustic and arthropod surveys at playa locations.

Shrub demographics

The shrub demographics research program is designed to explore the bottlenecks and constraints on woody plant dynamics in drylands. We established long-term shrub demographic plots adjacent to a subset of NPP sites to track dominant shrub density and growth and have been exploring limits to shrub encroachment associated with shrub-shrub competition.

Insect granivore impacts on vegetation establishment

We evaluated harvester ant (*Pogonomyrmex rugosus*) foraging behavior to assess harvesting of native seeds. We put seed cafeterias adjacent to existing *P. rugosus* nests and collected and counted seeds remaining after 24 h, while also distributing seed cafeterias at the 25 m nodes of a 100 m x 100 m grid, and mapped all *P. rugosus* nests in the grid, again collecting cafeterias after 24 h.

Biocrust diversity at Jornada and western drylands

We collected biocrust samples, soil from immediately below the biocrust, and soil next to the biocrust across a landform gradient. DNA sequences from biocrust and soil samples were analyzed for fungi, bacteria, and protists. For a cross-site study, we collected surface and subsurface soil samples from different ecological sites and states at Jornada Basin, Sevilleta Wildlife Refuge, Spring Mountains, and Reynolds Creek Watershed to investigate microbial community assembly and cross-domain co-occurrence.

Plant traits and mycorrhizal associations

NMSU student Isabella Johnson completed a series of greenhouse experiments assessing interactions between root traits (e.g., root density, root diameter) and species dependence on mycorrhizae. The species in her experiment overlap many of the species used in the RestoreNet program, of interest for restoration in the region.

Specific Objectives

See major goals (above).

Significant Results

Obj. 1: to understand how changing precipitation, atmospheric humidity, temperature, and land management control ecosystem state change in drylands

Nitrogen cycle acclimation to drought

As precipitation is expected to shift under climate change, we asked how both increases and decreases in water availability elicit ecological acclimation of the N cycle and how long this acclimation takes. Using foliar δ15N as a proxy for N cycling processes, we found that the slope of foliar δ15N decreases with mean annual precipitation across continents. However, at the Jornada, slopes of interannual foliar and soil δ15N increased with precipitation (Currier et al., 2026). The difference in directionality of spatial δ15N-precipitation slope compared to within-site, experimental δ15N-precipitation slopes revealed potential acclimation of the N cycle. Furthermore, we estimated rates of ecological acclimation—defined as convergence time for within-site δ15N-precipitation slopes to match the global model—to range from 11 to 18 years. We conclude N cycling is changing with precipitation amount and duration of the altered precipitation regime. We hypothesize that fast and slow ecological mechanisms, such as microbial processes and shifts in plant species dominance respectively, explain ecological acclimation of N cycling responses to climate change.

Global livestock destocking

Managed grazing is the most extensive land use on Earth. The prevailing narrative is that global rangelands, from grasslands to deserts, are being degraded by overgrazing due to overstocking. This perception arises from scientific literature, which contains an order of magnitude more studies on overstocking than on reductions in stocking rates. In contrast, over the past 25 years, regions representing almost half (42 %) of global livestock have experienced reductions in stocking rates rather than the expected increases. We evaluated socio-economic, technological, and climatic direct drivers, as well as indirect drivers, of global stocking patterns (Anadón and Sala, 2026; Figure 1). Trade and climate had no detectable effects, whereas technological shifts in meat consumption had an impact on stocking rates. Direct drivers were largely controlled by human population and gross domestic product. Wealthier regions, with slower population growth, greater feed supplementation, and reliance on non-grazing livestock, reduced stocking rates. Less affluent regions, facing rapid population growth and rising meat demand but limited technological and feed resources, increased stocking rates.

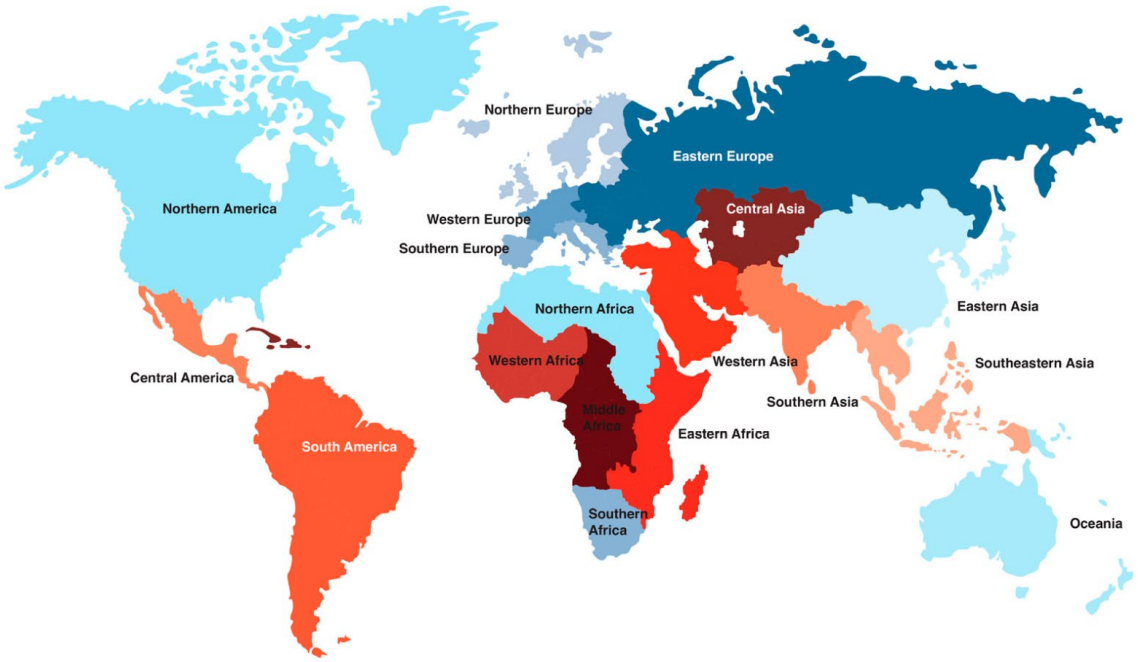

Figure 1. Global trends of livestock stocking rates (cattle, sheep, goats, buffalo) during 1999-2023, with blue areas representing destocking and red areas increasing livestock numbers. More affluent regions containing 42% of global livestock experienced destocking associated with stabilization, while less affluent regions experienced increases in range-fed livestock. Livestock densities for different species were normalized to FAO livestock units. After Anadon and Sala, 2026.

Obj. 2: to assess how carbon and nutrient cycling, and nutrient co-limitations, respond to and control dryland vegetation states

Eddy covariance flux network

We evaluated ecosystem carbon flux patterns across three sites spanning a shrub encroachment gradient in average and drought years. We found that temperature was consistently the strongest correlated environmental driver of gross primary production (GPP) and ecosystem respiration, while vegetation state determined ecosystem flux responses to soil moisture. In particular, soil moisture controls GPP at shrub-dominated sites in average rainfall years, but rainfall pulses control GPP at grass-dominated sites during drought (Browning et al., in prep; Figure 2). Analysis of eddy covariance data from the eastern bajada of the Jornada Basin was used to estimate relative transpiration rates between the dominant mesquite and creosote bush shrub species, with mesquite transpiration per unit canopy cover estimated to be 1.6 times that of creosote bush (Howlider et al, 2025).

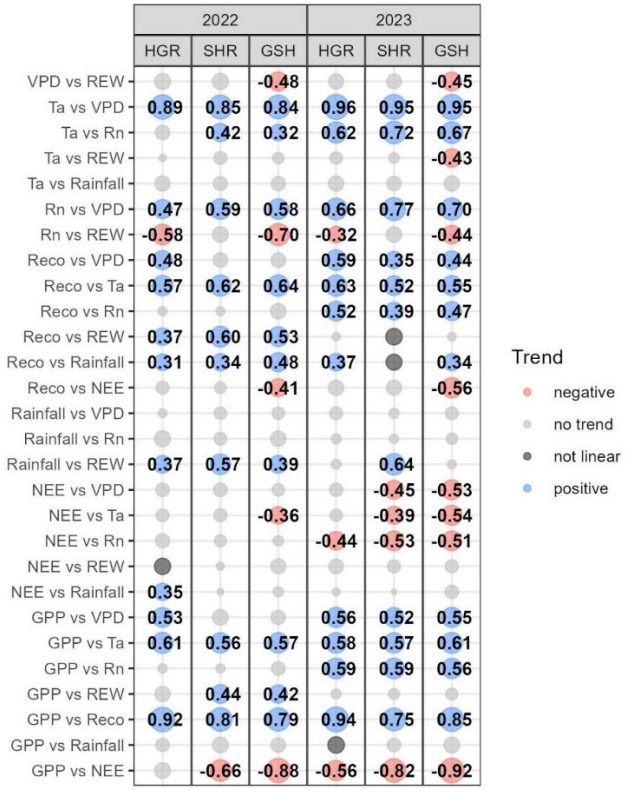

Figure 2. Pearson correlations between environmental drivers and ecosystem fluxes GEP, NEE, and Reco for Historic Grassland (HGR), Shrubland (SHR) and Grassy Shrubland (GSH) sites in 2022 and 2023. Fluxes were aggregated at weekly scale. We report Pearson correlations only when we found both Pearson and Kendall correlations to be significantly different from zero (alpha = 0.05). Pairs labeled "not linear" indicate cases in which the Pearson correlation coefficient was significant, but Kendall's Tau was not. From Browning et al. *Carbon flux implications of ecological state change in an arid rangeland ecosystem*. In Preparation.

Soil autochamber measurements

High temporal resolution soil CO2 exchange data give unprecedented insight into soil contributions to overall dryland carbon exchange and to the ways microsite climate controls compare with site-level climate controls. Soil CO2 exchange patterns are highly dynamic and relate to precipitation patterns, temperature, and microsite location relative to shrub canopies in unexpected ways. In particular, soil respiration under shrubs is considerably higher than in interspaces, as expected based on the Island of Fertility hypothesis, but time since previous rainfall is a stronger predictor of fluxes than rainfall amount (Denham et al., in prep; Figure 3).

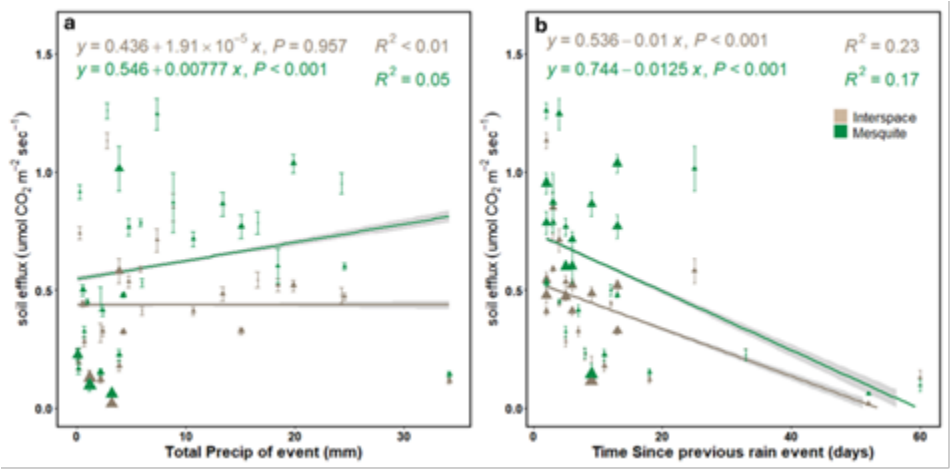

Figure 3. Soil efflux as a function of total event precipitation (a) and by the number of days since a previous event (b). Data point size reflects time since previous rain event (a) and event total precipitation (b). The total amount of precipitation received was not significant in explaining variability in soil efflux in the interspaces and marginally explained variance in the mesquite microhabitat (R2 = 0.04). Meanwhile, the time since a previous rain event explained 23 and 17% of the variability in soil efflux in the interspace and mesquite microhabitats, respectively (b). From Denham et al. *Hot vs cold precipitation events dictate direction of hysteretic trend of the soil efflux- soil temperature relationship in the Chihuahuan Desert*. In Preparation.

Microbial community contributions to carbon and nutrient cycling

Experimental additions of phosphorus indicate microbial metabolomic reinvestment from osmolyte and stress metabolites under low P conditions to microbial growth and plant secondary compound production with added P (Bista et al., in prep). A study of the fertile island effect (FIE) on soil fertility, microbial populations and metabolomics associated with shrub, grass and biocrust islands indicated that geomorphology influences overall soil fertility while enzymatic activity and nutrient levels varied among patch types relative to interspaces, suggesting that patch-scale processes operate independently of landscape-scale processes. We also found that

biocrusts can reach FIE levels comparable to plant patches, highlighting their role in dryland productivity (Stover et al 2025; Figure 4).

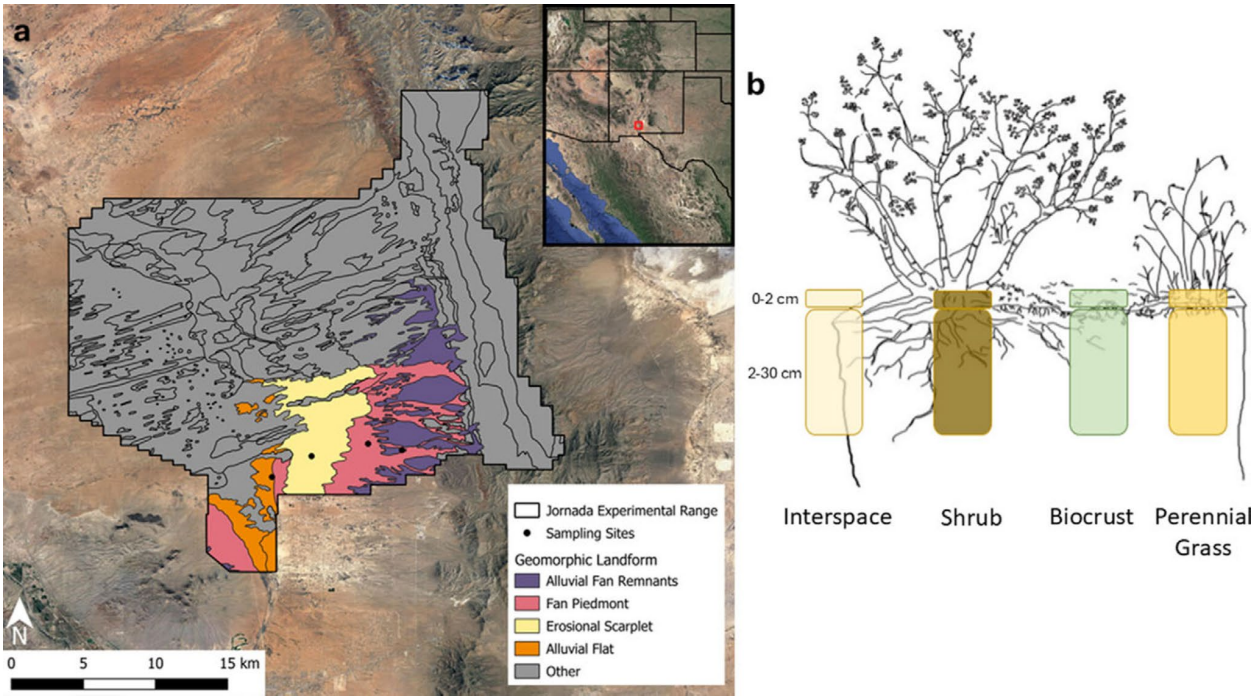

Figure 4. Effects of dryland islands on soil fertility and metabolomics (Stover et al., 2025) showing sampling sites and landforms (a) and patch types sampled (b).

Key Outcomes or Other Achievements

Obj. 3: to quantify how spatial connectivity with respect to wind and water transport can reinforce or reverse ecosystem state change

Hydrological connectivity

Ephemerally flooded playas are common in the southwestern United States and globally in drylands. Often formed in closed basins, playas are depressions which inundate infrequently from local precipitation and streamflow produced near the playa or from upland areas. Here, we used rain gauge-corrected precipitation from weather radar and water level measurements in 18 playas of the Chihuahuan Desert to identify precipitation thresholds leading to playa inundation over a 6.4-year period (Kimsal et al., 2026; Figure 5). Geospatial datasets on topography, soil properties, and vegetation cover were employed to determine the controls on inundation. Only 9.4% of all precipitation events above 1 mm led to inundation, with 69.8% of all inundations occurring during the North American monsoon (NAM, July-September). At the annual scale, playa inundation occurred when mean precipitation thresholds of 18.3 ± 7.5 mm (event total) and 12.0 ± 4.5 mm/hr (60-min intensity) were exceeded. Across all playas, inundation occurrence and volume were related most strongly to precipitation metrics and catchment area, with

secondary controls of soil and terrain properties. The explanatory power of the derived regressions describing the inundation response across the playas were significantly improved when considering their geological origin. As a result, the inundation response classification system could be applied to ephemeral playas in other arid and semiarid landscapes.

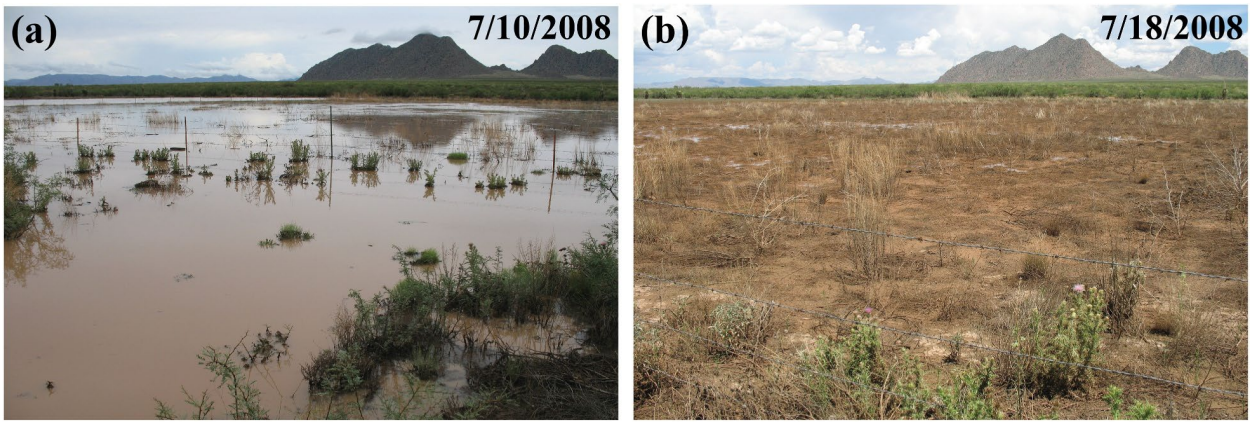

Figure 5. Ephemeral plays during (a) and one week after (b) a 50 mm storm leading to inundation at the Jornada Basin, after Kimsal et al., 2026.

Obj. 4: to characterize the biotic interactions underlying vegetation state change, including demographic processes, plant-microbe interactions, and trophic feedbacks.

The Ecotone study, bird and bat interactions

On the Ecotone Study, long-term exclusion of rodents and lagomorphs (21 years) led to two-to-threefold increases in perennial grass cover in shrub-encroached states, and improved perennial grass recovery from disturbance across all ecosystem states (Andreoni et al., 2025; Figure 6). Our results indicate small mammals create positive feedbacks mediated by changes in habitat structure that reinforce grassland–shrubland transitions in drylands. We also documented at least 14 bat species acoustically, eight of which were captured and confirmed in hand, at the Jornada Basin LTER site. Bats were active year-round, though activity peaked in summer as expected. This study will link vegetation, insect and insectivore dynamics to track trophic responses to alternative vegetation states. Preliminary results suggest activity of two functional groups, gleaning bats and open-air hawking bats, decreases with increasing shrub cover.

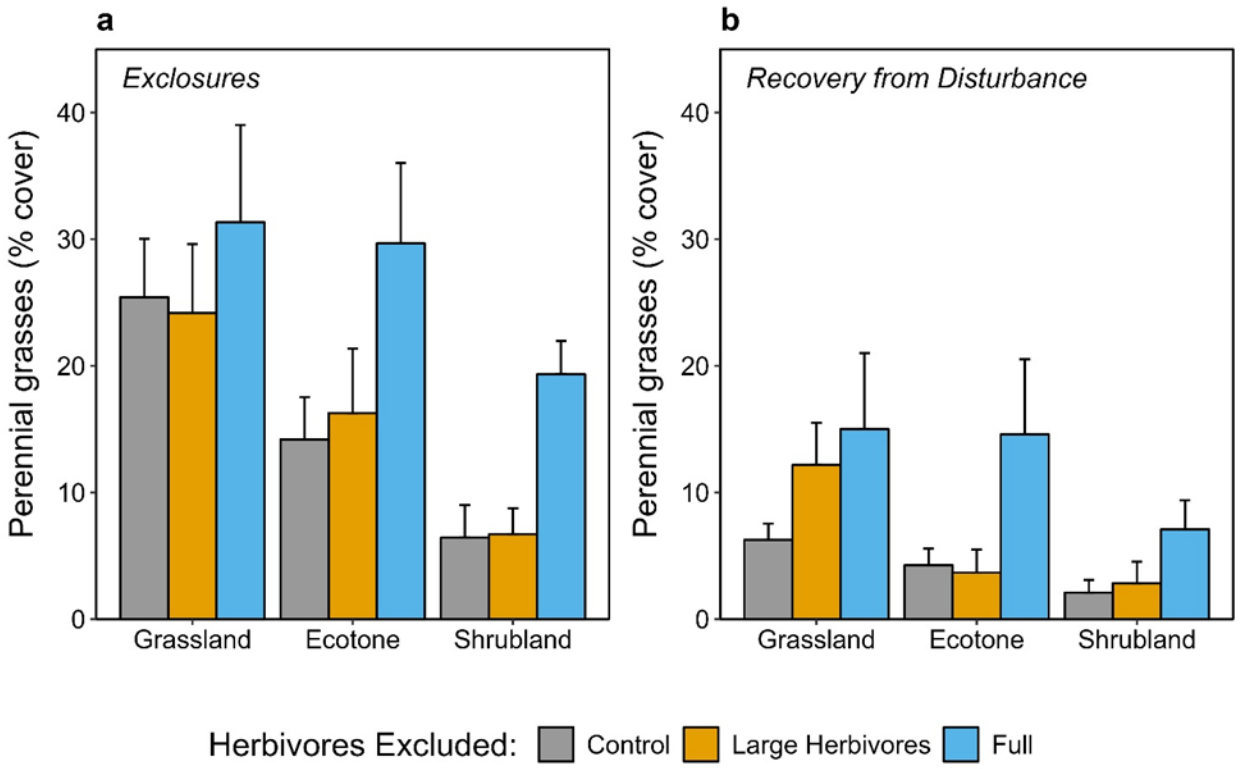

Figure 6. Perennial grass cover across ecosystem states within (a) 2 x 2-m herbivore exclosure treatments and control plots, and (b) disturbed 40 x 40-cm subplots within treatment and control plots. Exclosures were established in 2001, and disturbance was simulated within subplots through removal of all aboveground plant biomass. Bars represent means for percent foliar cover (+ 1 SE).(Andreoni et al., 2025; https://doi.org/10.1002/ecs2.70483).

Shrub Demography

A recent study (Roberts & Hanan, 2024; Figure 7) highlighted the role of shrub competition in limiting shrub volume to approximately 4,000 m^3/ha and canopy cover to approximately 35%, thus setting upper limits to shrub encroachment in drylands of the southwest. Furthermore, in a rare demonstration of competition directly reducing resource acquisition, we used a global sapflow database to show that woody plants subject to competition from neighbors have reduced water uptake (Roberts & Hanan, 2025; Figure 8), consistent with the inference that competition between woody plants can limit the maximum extent of woody plant encroachment.

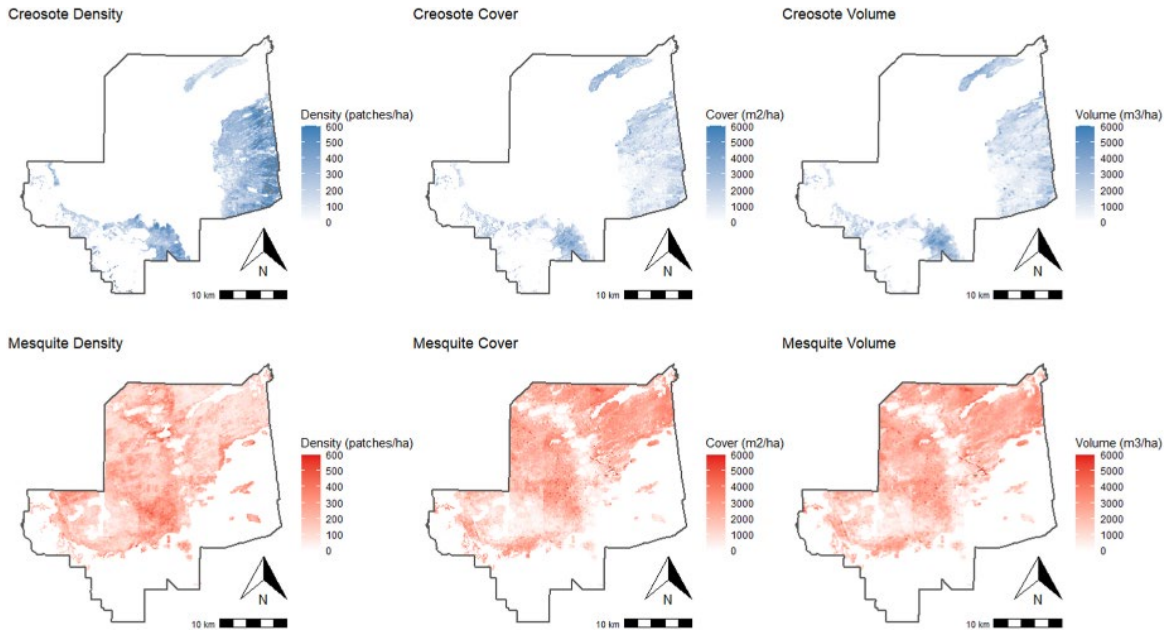

Figure 7. Shrubs of the Jornada Basin, showing stem density, canopy cover, and shrub volume in the dominant creosote and mesquite areas (at 1 ha). Maps were created through fusion of airborne imagery from NAIP at 1 m resolution (canopy cover, stem density), and canopy height from airborne lidar (USGS-3DEP at < 1 m), with 'volume' estimated from cover x height (Roberts and Hanan, 2024).

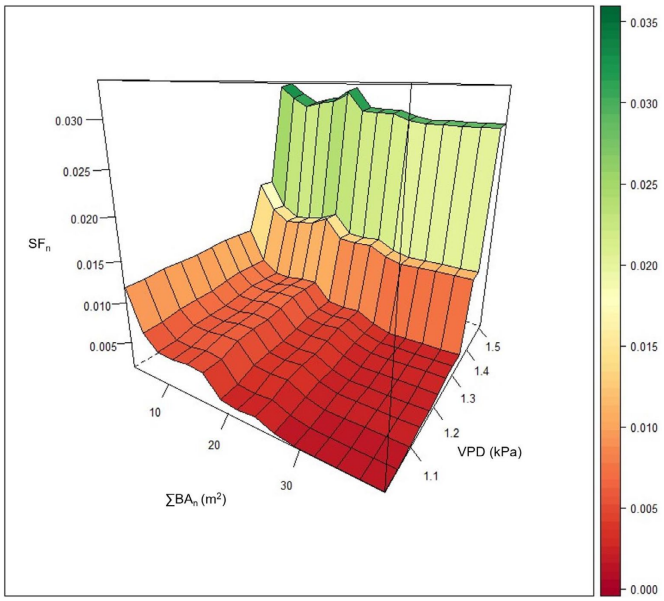

Figure 8. Partial dependence plot showing interactive effects of neighborhood basal area (BAn, m2) and vapour pressure deficit (VPD, kPa) on normalized sapflow SFn (mL/h/m2/mm) in an instrumented tree. VPD and BAn axis ranges were chosen to visualise interesting portions of the SFn ~ BAn + VPD relationship (BAn < 40m2; 1.0 kPa < VPD < 1.55 kPa), showing the primary impact of increasing VPD on sapflow and the secondary impact of neighborhood competition (Roberts and Hanan, 2025).

Insect granivore impacts on vegetation establishment

In the harvester ant experiment we established that few seeds were taken during early summer, but seed harvesting by *P. rugosus* peaked in August 2024, with up to 100% of seed taken for some species, with seed harvesting declining with distance from the nest (Lehnhoff et al. in prep).

Plant traits and mycorrhizal associations

We found that species with higher diameter roots have higher dependence on mycorrhizae for growth, a result that aligns with global expectations. However, the influence of mycorrhizae on plant survival is associated with other root traits, namely root tissue densities (Johnson et al., in prep). This new knowledge is essential for understanding recruitment failure in dryland settings and can help restoration practitioners better understand which species may require soil inoculations for success in dryland restoration projects. Johnson presented results of her work at the Jornada Short Course and the national and regional conferences of the Society for Ecological Restoration.

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

K-12 STEM Education and Educator Professional Development Accomplishments: JRN collaborates with the nonprofit Asombro Institute for Science Education to lead our K-12 education program, with the goals of broadening participation in science and increasing STEM education opportunities.

During more than 25 years of K-12 engagement, our team has created a suite of programs, detailed below. **From December 2024 – December 2025, these programs collectively reached 20,644 K-12 students, 730 teachers, and 1,602 other adults**. Accomplishments for each component are listed below.

1. Classroom Science Lessons and Schoolyard Field Trips: 18,043 K-12th grade students participated in 787 one- to two-hour classroom lessons and schoolyard field trips delivered by Asombro educators. Grade-specific K-12 lessons cover a variety of topics related to JRN research. All lessons are hands-on, aligned with Next Generation Science Standards, and designed using our 15-step development process, which includes scientist review, educator review, and pilot testing.

2. Field Trips: This year, we provided 26 field trips for 1,614 students, including hikes, hands-on activities, data collection, and interpretation around a central theme: desert plant and animal habitats (kindergarten and 1st grade), wind and water erosion (2nd and 3rd grade), using science to protect natural resources (4th and 5th grade), and desertification and restoration (6th-8th grade).

3. Desert Data Jam: The 12-year-old Desert Data Jam engages students in interpreting and communicating real data trends in creative ways (e.g., games, videos, physical models). In spring 2025, Asombro educators worked with 323 middle school students through four classroom

lessons. The top 52 projects were entered into the final competition and judged at least four times. The three top prize winners and ten honorable mention projects can be viewed on the Desert Data Jam website (https://asombro.org/desert-data-jam/).

4. Ecosystem Pen Pals based on <u>One Day in the Desert</u> Children's Book: We continued a postcard exchange with 5th grade students living near five LTERs, including New Mexico (JRN; 117 students), Alaska (NGA), Colorado (NWT), Puerto Rico (LUQ), and Virginia (VCR). Each class read <u>One Day in the Desert</u> (2017), the JRN's contribution to the LTER children's book series, in which the main character learns about her desert ecosystem and corresponds through postcards with children from other LTER sites. In our Ecosystem Pen Pals project, 5th graders in five locations replicated the main character's experience.

5. Teacher Workshops: We hosted five in-person and virtual workshops for 85 teachers on a variety of topics associated with the Jornada Basin LTER. For example, one workshop in October focused on how to use the schoolyard for outdoor learning at all grade levels.

6. Undergraduate Internship in Science Education: Each semester, the Asombro Institute hosts an undergraduate intern from New Mexico State University. During the paid internship, students learn about science education and outreach as they (a) accompany staff into local classrooms to assist with lessons, (b) assist with field trips, and (c) work on office projects to help prepare for upcoming lessons, workshops, and public events.

7. Family-Friendly Public Programs: We hosted or participated in other public programs throughout southern New Mexico and far west Texas, reaching 2,318 people of all ages through 21 public programs at nature parks, STEM nights, city parks, and public libraries. Seven Asombro events featured hands-on activity stations and expert talks to highlight research on animals and plants of the Chihuahuan Desert.

Education and Outreach in Higher Education and Other Contexts: During Year 1 of JRN-8, we continued outreach and education activities with undergraduate and graduate students, our own researchers and staff, and neighboring institutions and communities. These activities are focused on developing research and technical skills, building relationships with regional scientists, managers, and the public. Selected accomplishments are highlighted below.

1. Field Season Kickoff: At the start of the 2025 field season (early June), the student affairs committee and IM committee jointly organized a new Field Season Kickoff event. All graduate and undergraduates were encouraged to attend, and the event included an orientation to the Jornada Basin and associated research programs (JRN LTER, USDA JER), an activity on field safety and conduct expectations and procedures, lightning talks by graduate students, and a Jornada geospatial data workshop (described below). This event will be repeated annually.

2. Data Workshops: The JRN IM team organized several data science and research methods workshops in 2025. At the Field Season Kickoff event, graduate student rep Dylan Stover and lead IM Greg Maurer led a workshop on working with Jornada geospatial data using the open-source QGIS application. Maurer and USDA statistician Darren James also organized a Data Carpentry workshop during the Desert Ecology Short Course in August of 2025 that focused on using distributed version control systems (Git & GitHub) and the R tidyverse for research data management and analysis. Maurer also organized and instructed the "Ecological Data Synthesis:

A primer on essential methods and team science" short course, and co-instructed a workshop on using NEON and LTER biodiversity data, during the ESA 2025 Summer Meeting with contributors from the LTER Network, NEON, and the Environmental Data Initiative.

3. LTER-VII Graduate Fellow Report: During 2025, JRN-LTER graduated four PhD students and two MS students advised by project investigators. The JRN-LTER Graduate Student Research Fellowships Program provided direct support for 4 graduate students in 2025, with student training, mentoring, and research opportunities extending to an additional >15 graduate students with separate TA or RA support, at NMSU and partner institutions (UTEP, ASU, UCLA, UI). We continued our graduate networking and professional development forum (the online "Desert Discourse" series) to enhance opportunities for research and career advancement for graduate students, PIs, postdocs, and staff for networking, team building and professional development, and as a mechanism for retention and the promotion of a diverse next generation of ecological and STEM researchers.

4. LTER-VII REU Report: This year, student training and mentoring opportunities in dryland ecology included funding for 5 REU students. We continued REU enrichment programs including field-trips, socials, data-management training, graduate-student mentoring, and workshops to enrich the student experience.

5. Jornada Desert Ecology Short-Course: We hosted the annual Desert Ecology Short-Course at the Jornada this year. We hosted over 50 participants for three days of workshops, presentations, and field trips, with JRN researchers and students and collaborators from neighboring institutions and LTER sites.

6. Jornada Basin LTER Safety Training: JRN's field safety protocols and training handbook (https://lter.jornada.nmsu.edu/for-researchers) includes our code of conduct, sections on physical safety (specific to the Chihuahuan desert and our facilities), harassment and Title-IX policies, mental well-being, and other resources and reporting mechanisms. This handbook details expectations and procedures for field safety training and resource distribution , including a new "Borrow and Return Field Gear Locker" with personal protective equipment for field researchers to use if needed on their way to the field.

How have the results been disseminated to communities of interest?

JRN-LTER results have been communicated through scientific meetings, and publications in high impact journals (see Products Report). In this reporting period there were 30 published journal articles, and 6 graduate students completed MS thesis or PhD dissertations in addition to numerous conference presentations by project investigators, graduate and undergraduate research participants.

Jornada LTER continued engagement with agency staff, ranchers, and the interested public this past year. A symposium at the Society for Range Management in Monterrey, CA (11 February 2026) drew over 60 participants and focused on the management implications of non-equilibrium ecological systems based on work at JRN and other arid rangelands. A similar symposium on nonequilibrium rangeland management was also held at the International Rangeland Congress in

Adelaide, South Australia (4 June 2025). A talk on JRN long-term vegetation change was provided to the New Mexico Native Plant Society (4 October 2025, ~90 participants). There were numerous interactions between LTER scientists and individual ranchers to discuss the impacts of extreme drought on vegetation in southern New Mexico.

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

Obj. 1: to understand how changing precipitation, atmospheric humidity, temperature, and land management control ecosystem state change in drylands

We will continue our research on the impacts of climate variability and land use on ecosystem dynamics, including continued maintenance and monitoring of long-term manipulations of climate (rain-out and rain-on experiments and atmospheric water vapor), grazing intensity and nutrients. We will continue with the analysis and publication of data as well as writing of scientific manuscripts.

Obj. 2: to assess how carbon and nutrient cycling, and nutrient co-limitations, respond to and control dryland vegetation states

We plan to collect soil community data to complement the soil CO2 exchange and microclimate sensor data collected at our eddy covariance tower sites. We will integrate soil CO2 contributions to overall CO2 exchange, as influenced by soil type, rainfall, biocrust cover and vegetation type and compare these bottom up estimates with top down eddy covariance tower measurements. Pulse response dynamics will be a critical component of these studies.

Obj. 3: to quantify how spatial connectivity with respect to wind and water transport can reinforce or reverse ecosystem state change

The NEAT, TRIGGER and cross-scale experiments will continue to examine the influence of aeolian sediment flux on vegetation dynamics, establishment and mortality. Our hydrological measurements will continue to track microscale runoff dynamics, concentration of runoff into ephemeral streams and associated playa dynamics. We will analyze high resolution data now available on shrub and herbaceous cover to understand both hydrological and aeolian connectivity across the Basin, providing connectivity data to the full range of JRN-LTER studies.

Obj. 4: to characterize the biotic interactions underlying vegetation state change, including demographic processes, plant-microbe interactions, and trophic feedbacks

On the Ecotone Study, our focus will be to assess how changes in habitat structure and thermal landscapes affect temporal niches of predators, prey, and their interactions. We also will investigate how decimation of lagomorph prey due to a disease outbreak affects intraguild predation between canids across shrub encroachment gradients. We plan to expand our work on the Ecotone Study to sample bat activity and arthropods at playa lakes to address whether these

are important areas for sustaining bat populations in drylands even when water is absent. We will revisit the shrub demographic sites to census shrub seedling and adult growth and expand use of UAV data to support this long-term experiment. For our biocrust research, we plan to finish bioinformatic analyses, conduct statistical analyses, and consolidate findings for publication of a scientific manuscript.

Other Activities:

In the upcoming year, we will continue to provide K-12 classroom and schoolyard lessons, host field trips, host the 2026 Desert Data Jam, collaborate with educators at three other LTERs for the Ecosystem Pen Pals project, host at least four teacher workshops, support an undergraduate intern, and participate in at least 12 public education events.

PRODUCTS

i. Book

n/a

ii. Book chapter

n/a

iii. Peer reviewed journal or conference proceeding (12/2024-2/2026)

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iv. Thesis or Dissertation

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v. Datasets

(see attached at the end of the document)

IMPACT

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

The Jornada Basin LTER project (JRN-LTER) continues to advance understanding and theory of dryland ecosystem functioning, relevant to applied range management and broader ecological theory. In particular, JRN-LTER advances the application of ecological understanding of alternative stable states in dryland and their cascading implications for carbon, nutrients and trophic interactions. JRN also advances the study of how variable weather impacts dryland communities, and the development of ecological theory on state change and ecosystem dynamics in temporally and spatially complex environments.

What is the impact on other disciplines?

Jornada Basin LTER results are directly relevant to livestock, range management, and dryland ecosystems across the southwestern USA and other arid and semi-arid lands globally. JRN rangeland monitoring tools have been developed collaboratively with, and adopted for operational programs by, numerous Federal Agencies across the USA (e.g., BLM and NRCS) and globally (e.g. Mongolia and East Africa). JRN collaborations and outreach impact a variety of US and international, tropical, and temperate drylands.

What is the impact on the development of human resources?

Student training and mentoring opportunities in dryland ecology this year included direct support for 4 graduate students and multiple undergraduates, and participation of a larger number of students attending the Desert Ecology short-course and conducting research at the JRN with support from their JRN advisors, home universities, and independent research fellowships. We continue our commitment to mentoring of early career researchers, undergraduate and graduate networking and professional development (via the “Desert Discourse” Series, Desert Ecology short-course, and other activities).

What is the impact on teaching and educational experiences?

K-12, undergraduate and graduate students from our host communities and neighboring institutions (K-12, Community and 4-year Colleges) benefit from field research opportunities and education/outreach activities. Our teacher-training activities also provide teachers in southern New Mexico with diverse approaches to increase STEM education opportunities for their students, including classroom, schoolyard and field site opportunities.

What is the impact on physical resources that form infrastructure?

Nothing to report.

What is the impact on institutional resources that form infrastructure?

Nothing to report.

What is the impact on information resources that form infrastructure?

The JRN Information Management (IM) team continues to prioritize providing up-to-date research data described with consistent, high quality metadata, and we are improving the FAIR (findable, accessible, interoperable, and reusable) status of Jornada data each year. Since JRN's last annual report, we have published 18 new datasets via the EDI data repository, a more than 100% increase over the year before, and updated 227 unique existing datasets, which is similar to our activity in 2024 (Figure 9). Over the past year and a half, the IM team has focused on three primary enhancements to the JRN's data holdings and data management system. First, we have improved the discoverability and usability of our large collection of meteorology data by aggregating the many data tables that come from each weather station into one published dataset per station. This reduces the number of datasets that users must filter to find the data they need. Second, we are refining the process and codebase for quality-assuring JRN's core, long-term datasets and preparing them for publication. The JRN field crew has made changes to how field data are standardized and made available internally, and the IM team is currently refactoring the R packages and related workflows that manage these data, their metadata, and the publication process. Finally, the JRN IM team is engaged in a large rewrite of the Jornada Data Commons, a documentation system used by both researchers and data managers. The current web pages are being rewritten for clarity, new pages are being added, and the website is automatically rendered by the Quarto documentation system when changes are pushed to GitHub. Together, these improvements make JRN data more FAIR, increase the frequency of data publication, reduce inefficiencies and failures in our research and data management systems, and preserve institutional knowledge. The IM team has also spearheaded several data use and management training events for JRN students and investigators, including tutorials on using the ezEML metadata editor from the Environmental Data Initiative (EDI) repository, working with Git and GitHub as a researcher, using R for data analysis, and using spatial data from the Jornada GeoPortal. The JRN IM team engages frequently with the LTER Network's Information Management Committee, EDI, and other partners in the environmental science and data community to support and contribute to open science and sound data management practices.

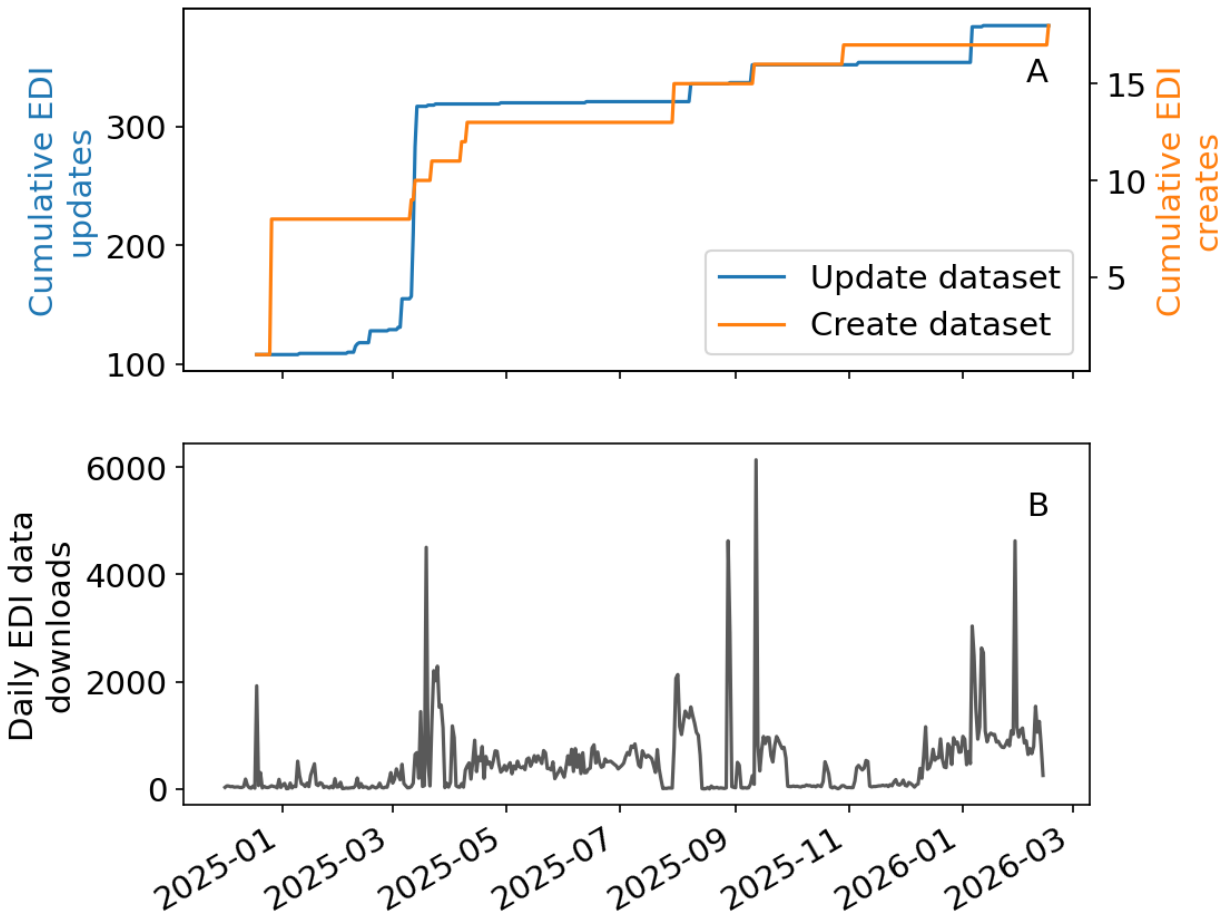

Figure 9. Publication and use of Jornada datasets during the 2025-2026 annual report period. Panel A shows cumulative updates to existing datasets published at the EDI repository (blue line) and new datasets published (gold line, 8 total). Panel B shows daily data downloads from the EDI data portal, which have been filtered to remove robots and other automated events.

What is the impact on technology transfer?

Nothing to report.

What is the impact on society beyond science and technology?

Our K-12 outreach program reaches most students in the local school district and many additional students in other school districts across New Mexico. Field, classroom/schoolyard, and family-friendly public programs increase awareness and understanding in the general public with major long-term benefits for environmental and STEM literacy. Jornada's K-12 outreach works with entire classes, schools, and sometimes districts. This helps promote science education by ensuring that all students are exposed to these enriching opportunities, not just those who have the resources to sign up for voluntary science education opportunities.

JRN Datasets newly added to EDI during Year 1 (227 in total)

1. Anderson, John. 2025a. “Jornada Basin LTER Cross-Scale Interactions Study (CSIS) Block 1 Meteorological Station: 1-Hour Summary Data: 2017 - Ongoing.” Environmental Data Initiative. https://doi.org/10.6073/PASTA/520A85EE21D6B3ABA1E1827048A157A3.
2. Anderson, John. 2025b. “Jornada Basin LTER Cross-Scale Interactions Study (CSIS) Block 1 Meteorological Station: 30-Minute Summary Data: 2017 - Ongoing.” Environmental Data Initiative. https://doi.org/10.6073/PASTA/D96E16B15ECEF50458A1209E74EFB5E0.
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9. Anderson, John. 2025i. “Jornada Basin LTER Cross-Scale Interactions Study (CSIS) Block 3 Meteorological Station: 1-Second Summary Precipitation Data: 2017 - Ongoing.” Environmental Data Initiative. https://doi.org/10.6073/PASTA/06A2614AF052750523F286E204AB89D6.
10. Anderson, John. 2025j. “Jornada Basin LTER Cross-Scale Interactions Study (CSIS) Block 3 Meteorological Station: 30-Minute Summary Data: 2017 - Ongoing.” Environmental Data Initiative. https://doi.org/10.6073/PASTA/8E607E13476982E2A96D84128C4EC01D.
11. Anderson, John. 2025k. “Jornada Basin LTER Cross-Scale Interactions Study (CSIS) Block 3 Meteorological Station: Daily Summary Data: 2013 - Ongoing.” Environmental Data Initiative. https://doi.org/10.6073/PASTA/B1DAE868D2F04F4D87737DB67DB9FE64.
12. Anderson, John. 2025l. “Jornada Basin LTER Cross-Scale Interactions Study (CSIS) Block 4 Meteorological Station: 1-Hour Summary Data: 2017 - Ongoing.” Environmental Data Initiative. https://doi.org/10.6073/PASTA/B9F41DA82AF4DE851C5342C3E8847F1C.
13. Anderson, John. 2025m. “Jornada Basin LTER Cross-Scale Interactions Study (CSIS) Block 4 Meteorological Station: 1-Second Summary Precipitation Data: 2017 - Ongoing.” Environmental Data Initiative. https://doi.org/10.6073/PASTA/A6281497E41470CB46B82B23921F0D29.
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23. Anderson, John. 2025w. “Jornada Basin LTER Cross-Scale Interactions Study (CSIS) Block 6 Meteorological Station: Daily Summary Data: 2013 - Ongoing.” Environmental Data Initiative. https://doi.org/10.6073/PASTA/DEB5A1CFE96AE83FE3194C9C6B73DC58.
24. Anderson, John. 2025x. “Jornada Basin LTER Cross-Scale Interactions Study (CSIS) Block 7 Meteorological Station: 1-Hour Summary Data: 2017 - Ongoing.” Environmental Data Initiative. https://doi.org/10.6073/PASTA/461EC2D4337CA603F33D6E05B55F7103.
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