2024
ANNUAL REPORT

CHIHUAHUAN DESERT RANGELAND RESEARCH CENTER

THE NMSU AGRICULTURAL EXPERIMENT STATION SUPPORTS RESEARCH THAT ADDRESSES REAL-WORLD PROBLEMS. RESEARCH IS AT THE CORE OF NMSU'S MISSION TO IMPROVE THE LIVES OF PEOPLE GLOBALLY.

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College of Agricultural, Consumer and Environmental Sciences
Agricultural Experiment Station

Chihuahuan Desert Rangeland Research Center

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This report has been prepared to aid Science Center staff in analyzing the results of various research projects from the past year and to record data for future reference. These are not formal Agricultural Experiment Station Report research results. The reader is cautioned against drawing conclusions or making recommendations as a result of the data in this report. In many instances, data represents only one of several years' results that will ultimately constitute the final formal report. Although staff members have made every effort to check the accuracy of the data presented, this report was not prepared as a formal release.

None of the data are authorized for release or publication without the written prior approval of the New Mexico Agricultural Experiment Station.

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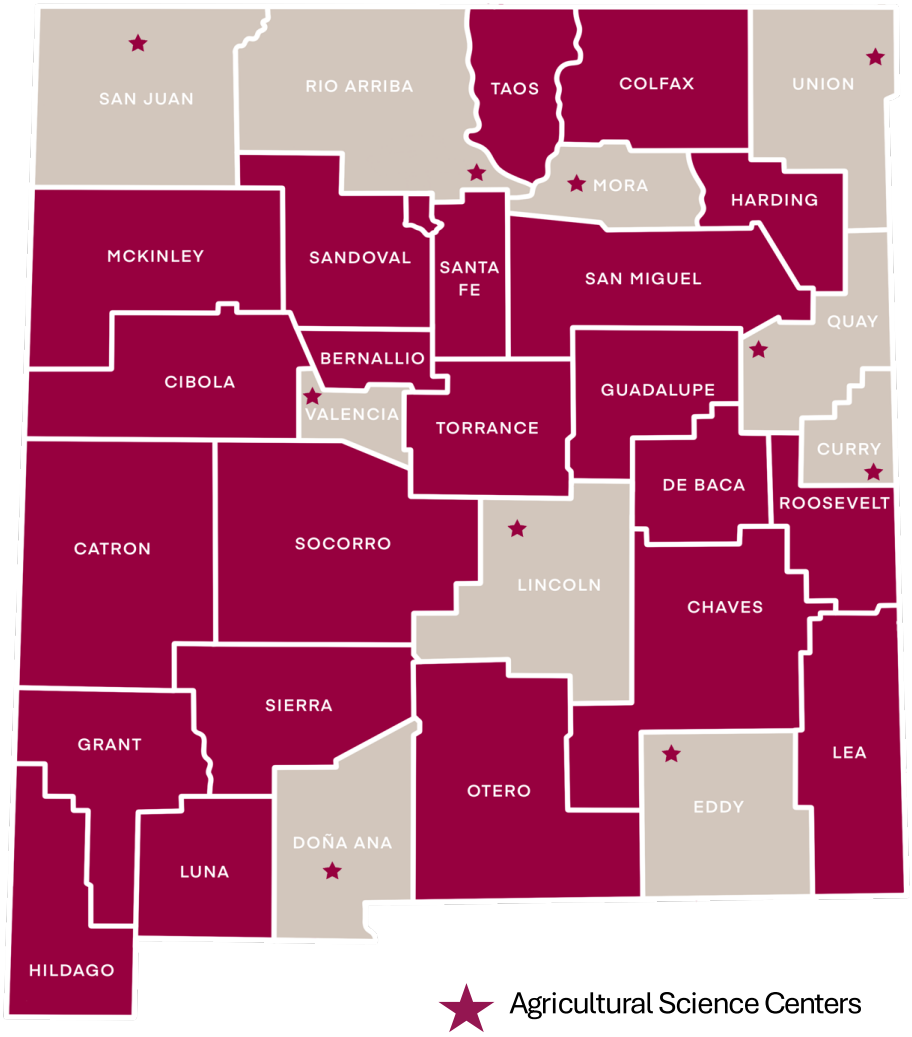
Agricultural Science Center Locations Map



Executive Summary

Throughout the past year, the Chihuahuan Desert Rangeland Research Center (CDRRC) has expanded its research on natural resources, livestock, and wildlife management in arid areas. Ongoing studies focus on wildlife interactions with the evolving desert landscape and the resulting effects on wildlife populations and their habitats. Additionally, research has grown on the presence of Oryx and the impacts of Oryx herbivory on Chihuahuan desert rangelands.

Agrivoltaics, the combined use of rangeland with agricultural production and photovoltaics is an expanded area of research for the CDRRC. Installation of photovoltaic panels will begin at the CDRRC in 2025 and will offer land managers, solar developers, and the public answers to the problems associated with the combined use of rangelands. Solar-array installations on the CDRRC will be used to study the effects of photovoltaic installations on rangeland ecosystem health, livestock behavior, and production.

The CDRRC experienced pivotal changes during 2024. With the continual drought and subsequent decreased forage production, CDRCC management decided to sell the historic herds of registered Brahman and Brangus cattle. However, the dispersal of the cattle did not mean the loss of the genetic base from years of developing efficient desert-adapted Bos Indicus cattle. The use of in vitro fertilization (IVF) has maintained the genetic base from the desert-adapted Bos Indicus cattle. With an eye on the future, CDRRC management plans to use the embryos developed from IVF to reestablish the registered herds and continue the development of cattle that are adapted to their desert environment and able to excel in the cattle industry.

The CDRRC's proximity to the NMSU Main Campus continues to provide for a convenient open-air lab that is utilized by students from a variety of NMSU departments. As part of their course, faculty from the NMSU Animal and Range Science and other NMSU departments frequently bring students to the CDRRC for instructional labs. Additionally, the CDRRC is visited by the Asombro Institute and K-12 students from the Las Cruces Public Schools to learn about environmental stewardship and ranching sustainability.

Research Highlights

New Mexico State University Agrivoltaics Research Program

Investigators: Lara Prihodko, Andrew Cox, Kevin Lombard, Stephanie Walker, Niall Hanan, Marisa Thompson, Olga Lavrova, Israel Joukhadar, Brandon Bestelmeyer, Sheri Spiegal, Greg Cooper, Derek Whitelock, and Paul Funk

Collaborating Agricultural Science Centers: Farmington Agricultural Science Center and Leyendecker Plant Science Center

Project Overview: Agricultural lands in New Mexico offer ideal conditions for renewable energy development due to abundant land, high solar irradiance, and supportive federal and state policies. However, converting agricultural lands to energy production presents both risks and benefits. To address this, New Mexico State University has launched an agrivoltaics research program to assess the agronomic and environmental impacts of solar energy integration. This project aims to construct and instrument three agrivoltaic research arrays to explore ways to enhance agricultural productivity, optimize water use, and support rural economies while minimizing environmental costs and maximizing the benefits of clean, renewable energy in arid regions.

Meeting the Needs of New Mexico: This project addresses New Mexico's agricultural, environmental, and economic challenges while maximizing its renewable energy potential. By utilizing the state's vast agricultural lands and high solar irradiance, it promotes dual land use for both farming and energy generation, reducing competition for space. In an arid climate, agrivoltaics enhance water conservation by minimizing evaporation and improving rainfall harvesting. Economically, the project diversifies farmers' income and strengthens rural economies through solar energy opportunities. Additionally, agrivoltaics offer environmental benefits such as reducing soil erosion, regulating temperatures, and supporting pollinators. Expanding clean energy production also enhances energy security by reducing fossil fuel dependence.

Impacts: This project will have a significant impact on New Mexico's agricultural sustainability, water conservation, rural economies, and renewable energy development. By integrating solar energy with farming, it enhances land productivity while reducing competition for resources. Improved water use efficiency and reduced evaporation will help address the state's water scarcity challenges. Farmers and rural communities will benefit from diversified income opportunities and job creation in the renewable energy sector. Additionally, agrivoltaics will promote environmental health by reducing soil erosion, regulating temperatures, and supporting pollinators. Overall, this initiative strengthens New Mexico's leadership in clean energy while ensuring agricultural and economic resilience.

Funding Acknowledgement: Congressionally directed spending funded through the Department of Energy

The Interactive Effects of Bats and Arthropods on Shrub Encroachment Dynamics in the Chihuahuan Desert

Investigator: Theresa Laverty (tlaverty@nmsu.edu)

Project Overview: Dryland grasslands around the world are experiencing woody plant encroachment, impacting the animals that reside in these habitats. Bats are one of the most species-rich groups of mammals in arid environments, and they collectively play an important role in controlling arthropod populations. To test how these nocturnal aerial insectivores are affected by—and potentially influence—shrub encroachment in arid landscapes, NMSU researchers are studying bat and arthropod communities and their trophic interactions across a grass–shrub gradient in the northern Chihuahuan Desert. They also plan to quantify the effects of predation by bats using exclosure plots deployed in the summer across spatial blocks of grass-dominated, shrub-dominated, or ecotone habitats used in other long-term experiments at the Jornada Basin Long Term Ecological Research (LTER) site in southern New Mexico.

Meeting the Needs of New Mexico: Bats suppress insect populations, including economically significant pests that damage agricultural crops. These nocturnal aerial insectivores are estimated to provide the U.S. agricultural industry with about $22.9 billion a year of natural pesticide services. In the United States, bat species richness peaks at 29 species in the northern Chihuahuan and Sonoran Deserts of the arid Southwest, and nearly half (45%) of those are considered Species of Greatest Conservation Need in Arizona and New Mexico's State Wildlife Action Plans. This research will provide information about how shrub encroachment may impact habitat quality for different bat species and offer management recommendations to conserve bats in arid environments.

Impacts: The impacts of this research not only reach the people of New Mexico but also incorporate undergraduates from New Mexico State University, a Hispanic-serving institution, in paid research positions and via course-based undergraduate research experiences. Findings from this project will be used to enrich courses offered by PI Laverty in the NMSU Department of Fish, Wildlife, and Conservation Ecology, including courses on Mammalogy, Natural History of the Vertebrates, and Wildlife Techniques and Analysis courses. These courses will be enhanced through optional weekend field trips to the Jornada Basin research sites, and additional field experiences in closer proximity to the NMSU campus during normal instruction times.

Funding Acknowledgement: National Science Foundation, Building Research Capacity for New Faculty in Biology (NSF BRC-BIO), award # 2335008

Cattle-Oryx Interactions on Chihuahuan Desert Rangelands of the Chihuahuan Desert Rangeland Research Center

Investigators: Louis C. Bender and Andrew Cox

Project Overview: Increasing populations of oryx might decrease forage availability for cattle, especially given the relatively low forage abundance in Chihuahuan desert habitats. Continued evaluation of oryx-cattle interactions on the CDRRC is aimed at determining the nature of oryx-cattle forage interactions, i.e., whether exploitation competition is occurring, or whether other foraging interactions such as facilitation characterize their co-use of Chihuahuan desert rangeland. Previous work on the CDRRC found extensive overlap in distribution between oryx and cattle, with each herbivore keying on different aspects of the landscape while being strongly associated in their distributions. This project extends that work by determining the potential impact of oryx herbivory on livestock, and combined oryx-livestock herbivory on rangeland health. Determining forage co-use by oryx and cattle will help managers set sustainable stocking levels for livestock and identify sustainable oryx densities on shared rangeland.

Meeting the Needs of New Mexico: Oryx currently occupy >15,000 km2 in southern New Mexico, including New Mexico State University's CDRRC where numbers have increased to >180 by 2023, a density of ca. 10/km2 in core oryx-use areas. Introductions of exotic wildlife have the potential to impact domestic livestock on shared ranges; however, these impacts are seldom rigorously evaluated. Previous work on the CDRRC found concerns regarding the aggressive behavior of oryx impacting livestock to be unwarranted. This project extends that work by determining the potential impact of oryx herbivory on livestock and rangeland health on Chihuahuan desert rangelands co-used by oryx and livestock.

Impacts: Determining forage co-use by oryx and cattle will help managers set sustainable stocking levels for livestock and identify sustainable oryx densities on shared rangeland. Oryx occupy ca. 82% of the CDRRC; total numbers are >180 and increasing at >13% annually. Despite very little forage production in 2023-24, preliminary data has shown differences in levels of use of some perennial grasses on CDRRC, depending on whether exposed or not-exposed (i.e., located within grazing exclosures) to large herbivore grazing despite significant destocking of cattle. Differences were more common in areas associated with higher soil moisture (playas) and hence greater likelihood of green forage.

Impacts of Desertification on Wintering Sparrows in the Chihuahuan Desert of Southern New Mexico

Investigators: Juliemar Cuevas-Hernandez (jcuevas2@nmsu.edu), Dr. Aaron C. Young, Dr. Martha J. Desmond, and Dr. Timothy Wright

Project Overview: Desertification processes are actively changing the Chihuahuan Desert landscape towards a highly shrub-encroached habitat, yet shrub-associated avian species are exhibiting declines. This study aims to gain a better understanding of the impacts of desertification on Sagebrush (*Artemisiospiza nevadensis*) and Black-throated sparrows (*Amphispiza bilineata*) during the winter season, an understudied portion of their lives. Distance sampling and vegetation surveys will assess the impact of desertification on sparrows' abundance and body condition. Avian predators that predate on these sparrows will also be surveyed for their abundance across sites. Understanding the impacts of desertification on two declining and understudied sparrow species within a changing landscape will help inform important management decisions for their conservation.

Meeting the Needs of New Mexico: The survey sites for this project are the same transects visited during the winters of 2003 to 2006, more than 20 years ago, which investigated grassland and shrubland bird communities. Comparing newly collected data to a historic data set will help inform how this portion of the Chihuahuan Desert has changed over time and provide insight into the status of avian populations and habitat changes. Understanding these long-term environmental changes within an agricultural context can help inform decision-making in New Mexico agriculture, to help support both the needs of ranchers and the wildlife that share these spaces.

Impacts: This research revisits transects surveyed during the early 2000's for grassland and shrubland bird communities and their associations with shrub-encroached habitats. The project will specifically assess two sparrow species, Black-throated and Sagebrush Sparrows, that use the Chihuahuan Desert during portions of their nonbreeding season. Data collected will include assessing the vegetation, avian predator and sparrow abundances, and sparrow body condition across sites. This research will help inform how the species of interest are being influenced by changes in the habitat such as shrub encroachment and other processes associated with desertification. Additionally, comparisons of avian communities and vegetation structure from data collected over 20 years apart will help gain an understanding of how these aspects of the environment have changed throughout the years. These findings will help inform decision-making related to declining avian species and their associations with a changing landscape.

Funding Acknowledgement: Supported in part by - USDA NIFA's HSI program (Award # 2022-77040-37638); USDA National Institute of Food and Agriculture, NextGen Program, Award No. 2023-70440-40158; NMSU ENHANCEMENT Program funded by USDA-NIFA.

RestoreNet: Distributed Field Trial Network for Dryland Restoration

Investigators: Seth Munson (USGS), Laura Shriver (USGS), Magda Garbowski (NMSU, garbowsk@nmsu.edu), Caroline Havrilla (Colorado State University), Elise Gornish (University of Arizona), Catherine Gehring (Northern Arizona University)

Project Overview: RestoreNet is a co-produced research network that systematically tests dryland restoration treatments across environmental gradients in the Southwest. There are currently 25 RestoreNet sites spread across five states and seven ecoregions in the Southwest, including two sites in New Mexico, and one at NMSU CDRRC. RestoreNet experiments test the same treatments across sites that are placed across a network that spans environmental gradients, so researchers can see how treatments and environmental factors interact to influence outcomes. At the CDRRC, researchers are planning to implement RestoreNet 2.0: Harnessing livestock and microbes to improve rangeland productivity and soil health. At this site, treatments will include soil pits, seed balls, and live topsoil inoculation aimed at improving native plant establishment and soil health. Five other sites in the RestoreNet network will also receive targeted livestock treatments.

Meeting the Needs of New Mexico: RestoreNet networked restoration experiments aim to produce best management practices and actionable science that is specific to RestoreNet sites, ecoregions, and the whole network. The sites at the CDRRC and Jornada have produced and will continue to produce site-specific restoration information on what treatments do and do not work. RestoreNet results are also publicly available and summarized in research briefs, publications, and newsletters, and the protocol to establish a RestoreNet site is publicly available to individual land managers and owners can use RestoreNet methods to answer restoration questions of their own.

Impacts: RestoreNet sites directly benefit land managers and owners, as researchers co-produce knowledge by working together to decide which treatments to test, interpret results and explore new ideas; they serve as restoration demonstration sites; and the small test plots reduce cost and build understanding that later supports larger scale projects. RestoreNet research also improves restoration outcomes, by testing standardized treatments across environmental gradients to explore how treatments interact with temperature, precipitation, and site-specific characteristics to influence outcomes.

Funding Acknowledgement: USGS programmatic funding from the Ecosystems Mission Area, and a grant from the Western Sustainable Agriculture Research and Education Award.

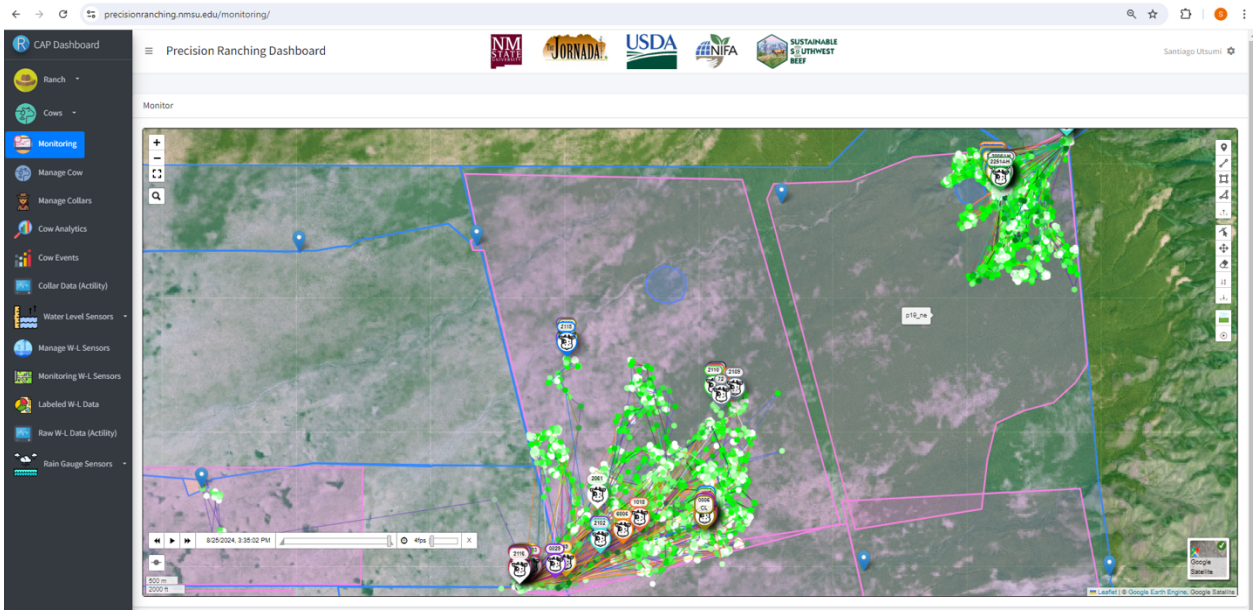
Precision Ranching in Southwestern Rangelands

Investigators: Santiago Utsumi, Brandon Bestelmeyer, Mehmet Bakir, Craig Gifford, Emile Elias, Marcy Ward, Andrew Cox, Rick Estell, and Sheri Spiegal

Project Overview: Virtual fencing coupled with remote sensing and sensors to monitor rangeland and livestock were integrated in a ranch dashboard monitoring system. The new system is intended to fulfill the needs for applying adaptive management in ranches of the southwest.

Meeting the Needs of New Mexico: Ranchers oversee large areas of arid and semiarid rangeland, facing challenges to check on herds and forages regularly. This issue typically leads to significant ecological and economic losses due to delayed management responses. Scientists affiliated with NMSU-CDRRC integrated new hardware and software to help monitor rangeland and livestock and help ranchers address those issues.

Impacts: CDRRC contributed to the development of a Ranch Dashboard Monitoring System utilizing wireless technology. The system was deployed across c.a. 500,000 acres of rangeland on eight southwestern ranches in four states, monitoring 700 head of cattle, and has attracted $2.5 million to support new on-ranch deployments in NM and other western states.



*F*igure 1. Dashboard developed by scientists at NMSU and USDA-ARS JER. The system has become the backbone for applications of virtual grazing (pink polygons) seeking to manage grazing pressure on large pastures of extremely heterogeneous rangeland. Virtual fencing management considers estimations of 16-d changes of the growth rate of herbaceous rangeland plants by the Rangeland Analysis Platform (https://rangelands.app/) along with detections of areas of greater livestock concentration (hotspots), real-time tracking of livestock behavior and drinking water in tanks done by the dashboard tool. A demonstration of the system is accessible on-line at https://drive.google.com/file/d/1-2YNcXUv3qTnsm3rgQhar3A9HRlhP_po/view?usp=drive_link.

LTER Collaborative Research

The LTER research is a multi-scale approach that integrates patch scale processes, landscape-scale states, and basin scale topographic and edaphic context. This contributes to the development of rangeland health monitoring practices that lead to a better understanding of landscape state changes that support rangeland management efforts across NM.

There were 32 LTER-associated multi-site research studies ongoing on the CDRRC during 2024. Of these, 28 are long-term studies of at least 10 years, the earliest beginning in 1982. These are monitoring studies looking at long-term effects of climate and abiotic drivers of wind and water, vegetation dynamics, plant annual net primary productivity, soil moisture, meteorological data including rainfall, small mammal population dynamics, soil biocrust, and bat-arthropod food web.

2024 JRN LTER Publications that Included Research Locations on the CDRRC

[LTER JRN funded] Roberts, Trevor, and Niall P. Hanan. "Thinning Relationships of Woody Encroachers in a US Southwestern Shrubland." *Journal of Arid Environments* 225 (December 1, 2024): 105245. https://doi.org/10.1016/j.jaridenv.2024.105245.

Cleland, Elsa E., and E. M. Wolkovich. "Effects of Phenology on Plant Community Assembly and Structure." *Annual Review of Ecology, Evolution, and Systematics* 55, no. Volume 55, 2024 (November 4, 2024): 471–92. https://doi.org/10.1146/annurev-ecolsys-102722-011653.
[The above paper cites use of JRN LTER dataset from NPP C-CALI study on CDRRC in pasture 10.

Duniway M. 2023. Jornada Basin LTER: Wireless meteorological station at NPP C-CALI site: Daily average soil volumetric water content data: 2013 - ongoing Ver. 36. . Environmental Data Initiative. https://doi.org/10.6073/pasta/48000a94106fa0284305f9c556c7814a]

[LTER JRN funded] Myers, Emily R., Dawn M. Browning, Laura M. Burkett, Darren K. James, and Brandon T. Bestelmeyer. "Novel Use of Image Time-Series to Distinguish Dryland Vegetation Responses to Wet and Dry Years." *Journal of Remote Sensing*, July 8, 2024, remotesensing.0190. https://doi.org/10.34133/remotesensing.0190.

[LTER JRN funded] Wagnon, Casey J., Bradley J. Cosentino, and Robert L. Schooley. "Linking Animal Personality and Habitat Restoration for a Keystone Species." *Animal Behaviour* 212 (June 1, 2024): 13–30. https://doi.org/10.1016/j.anbehav.2024.03.003.

[LTER JRN funded] Wagnon, Casey J., Brandon T. Bestelmeyer, and Robert L. Schooley. "Dryland State Transitions Alter Trophic Interactions in a Predator–Prey System." *Journal of Animal Ecology* n/a, no. n/a (2024). https://doi.org/10.1111/1365-2656.14197.

[LTER JRN funded] Andreoni, Kieran. "Mammalian Herbivores Reinforce Ecological State Transitions in the Chihuahuan Desert." Thesis, University of Illinois at Urbana-Champaign, 2024. https://hdl.handle.net/2142/124466.

[LTER JRN funded] Andreoni, Kieran J., Brandon T. Bestelmeyer, David C. Lightfoot, and Robert L. Schooley. "Effects of Multiple Mammalian Herbivores and Climate on Grassland–Shrubland Transitions in the Chihuahuan Desert." *Ecology* n/a, no. n/a (2024): e4460. https://doi.org/10.1002/ecy.4460.

[LTER JRN funded] Schaefer, Anthony. "Linking Biological Soil Crust Abundance, Distribution, and Composition to Ecological Site and State in the Chihuahuan Desert." M.S., New Mexico State University, 2024. https://www.proquest.com/docview/3066841575/abstract/8B78BA841E9E4B77PQ/1.

[LTER JRN funded] Hurtado, Ruby Yaritza. "Landscape Position Impacts on the Water Balance in the Chihuahuan Desert: Insights From Cosmic-Ray Neutron Sensing at Upland Watershed and Downstream Playa Sites." M.S., Arizona State University, 2024. https://www.proquest.com/docview/3089816174/abstract/32C7AF6343AC4BDEPQ/1.

[LTER JRN funded] Lee, Steven. "Biological Interactions and Disturbance in Arid Ecosystems: Examples From the Great Basin, Mojave, and Northern Chihuahuan Deserts." Ph.D., New Mexico State University, 2024. https://www.proquest.com/docview/3098531407/abstract/56E81E1291C84618PQ/1.

[LTER JRN funded] Eldridge, David J., Jingyi Ding, Josh Dorrough, Manuel Delgado-Baquerizo, Osvaldo Sala, Nicolas Gross, Yoann Le Bagousse-Pinguet, et al. "Hotspots of Biogeochemical Activity Linked to Aridity and Plant Traits across Global Drylands." *Nature Plants* 10, no. 5 (May 2024): 760–70. https://doi.org/10.1038/s41477-024-01670-7.

[LTER JRN funded] Wojcikiewicz, Robert, Wenjie Ji, and Niall P. Hanan. "Quantifying Shrub–Shrub Competition in Drylands Using Aerial Imagery and a Novel Landscape Competition Index." *New Phytologist* 241, no. 5 (2024): 1973–84. https://doi.org/10.1111/nph.19505.

[LTER JRN funded] Hanan, N. P., and L. B. Hutley. "Editorial: Current Insights in Drylands." *Frontiers in Environmental Science* 12 (March 6, 2024). https://doi.org/10.3389/fenvs.2024.1391211.

[LTER JRN funded] Ghimire, Rajan, Deb Raj Aryal, Niall P. Hanan, Sawssan Boufous, Owen Burney, O. John Idowu, Hatim M. E. Geli, Brian Hurd, and Lara Prihodko. "Carbon Sequestration through Sustainable Land Management Practices in Arid and Semiarid Regions: Insights from New Mexico." *Agrosystems, Geosciences & Environment* 7, no. 4 (2024): e70019. https://doi.org/10.1002/agg2.70019.
[soil organic carbon by depth included data from McKenna et al 2022, who was a PhD student at the time. Data was from multiple playa sites on the Jornada, including the CDRRC. See Figure 2 in pub for that reference.]

[LTER JRN assisted] Terry, Tyson J., Osvaldo E. Sala, Scott Ferrenberg, Sasha C. Reed, Brooke Osborne, Samuel Jordan, Steven Lee, and Peter B. Adler. "Disturbance Amplifies Sensitivity of

Dryland Productivity to Precipitation Variability." *Science Advances* 10, no. 30 (July 26, 2024): eadm9732. https://doi.org/10.1126/sciadv.adm9732.

[LTER JRN assisted] Cocciardi, Jennifer M., Ava M. Hoffman, Diego F. Alvarado-Serrano, Jill Anderson, Meghan Blumstein, Emma L. Boehm, Lana G. Bolin, et al. "The Value of Long-Term Ecological Research for Evolutionary Insights." *Nature Ecology & Evolution* 8, no. 9 (September 2024): 1584–92. https://doi.org/10.1038/s41559-024-02464-y.

[LTER JRN assisted] Nyachoti, Syprose K., Victor H. Garcia, Curtis Monger, Craig Tweedie, Thomas E. Gill, Lixin Jin, and Lin Ma. "Uranium-Series and Strontium Isotope Systematics in Soil Carbonates from Dryland Critical Zones: Implications for Soil Inorganic Carbon Storage and Transformation." *Geochimica et Cosmochimica Acta* 377 (July 15, 2024): 34–51. https://doi.org/10.1016/j.gca.2024.05.020.

By the Numbers

Research Publications

- Balazs, K.R., Munson, S.M., Havrilla, C.A. and Butterfield, B.J., 2022. Directional selection shifts trait distributions of planted species in dryland restoration. Journal of Ecology, 110: 540-552. DOI: https://doi.org/10.1111/1365-2745.13816
- Balazs, K.R., Munson, S.M. and Butterfield, B.J. 2022. Functional composition of plant communities mediates biomass effects on ecosystem service recovery across an experimental dryland restoration network. Functional Ecology 36: 2317-2330. DOI: https://doi.org/10.1111/1365-2435.14129
- Bender, L. C., and A. Cox. 2024. Co-distribution of Cattle and Exotic Oryx on Chihuahuan Desert Rangeland, South-Central, New Mexico Rangeland Ecology & Management, 93 (2024): 81-86
- Bestelmeyer, B.T., S.E McCord, D.M. Browning, L.M. Burkett, E. Elias, R.E Estell, J.E. Herrick, D. James, S. Spiegal, S.A. Utsumi, N.P. Webb, and J. Williamson. 2024. Fulfilling the promise of digital tools to build rangeland resilience. Frontiers in Ecology and the Environment, 2024: e2736.
- Butterfield, B.J., and Munson, S.M., 2023, Do seeding and seedling planting result in similar restored plant communities? Applied Vegetation Science 26: e12758. DOI: https://doi.org/10.1111/avsc.12758
- Butterfield, B.J, Munson, S.M., and Farrell, H.L., 2023, Plant water-use strategies predict restoration success across degraded drylands. Journal of Applied Ecology 60: 1170-1180. DOI: https://doi.org/10.1111/1365-2664.14393
- Farrell, H.L., Munson, S.M., Butterfield, B.J., Duniway, M.C., Faist, A.M., Gornish, E.S., Havrilla, C.A., Larios, L., Reed, S.C., Rowe, H.I., Laushman. K.M., and McCormick M.L.., 2023, Soil surface treatments and precipitation timing determine seedling development across southwestern US restoration sites. Ecological Applications 33(4): e2834. DOI: https://doi.org/10.1002/eap.2834
- Havrilla, C., A., Munson, S.M., Yackulic, E.O., Butterfield, B.J., 2021, Ontogenetic trait shifts: Seedlings display high trait variability during early stages of development, Functional Ecology 35: 2409-2423. DOI: https://doi.org/10.1111/1365-2435.13897
- Havrilla, C.A., Munson, S.M., McCormick, M.L., Laushman, K.M., Balazs, K.R. and Butterfield, B.J., 2020. RestoreNet: An emerging restoration network reveals controls on seeding success across dryland ecosystems. Journal of Applied Ecology 57: 2191-2202. DOI: https://doi.org/10.1111/1365-2664.13715
- McIntosh, M.M., S.A. Utsumi, S. Nyamuryekung'e, R.E. Estell, A. Cox, D. Duni, A.F. Cibils, Q. Gong, A. Waterhouse, J. Holland, H. Cao, L. Boucheron, H. Chen, and S. Spiegal. 2023. Deployment of a LoRa-WAN near real-time precision ranching system on extensive desert rangelands: what we have learned. Applied Animal Science 39, 257-362.
- Nyamuryekung'e, S., G. Duff, S.A. Utsumi, R. Estell, M.M. McIntosh, M. Funk, A. Cox, H. Cao, S. Spiegal, A. Perea, and A.F. Cibils. 2023. Real-Time Monitoring of Grazing Cattle Using LORA-WAN Sensors to Improve Precision in Detecting Animal Welfare Implications via Daily Distance Walked Metrics. Animals 13, 2624.
- Winkler Z., L.E. Boucheron, S.A. Utsumi, S. Nyamuryekung'e, M. McIntosh, R.E. Estell. 2024. Effects of dataset curation on body condition score (BCS) determination with a vision transformer (ViT) applied to RGB+depth images. Smart Agricultural Technologies, 9: 100482.
- Yang, B., Balazs, K.R., Butterfield, B.J., Laushman, K.M., Munson, S.M., Gornish, E.S., and Barberán, A., 2022, Does restoration of plant diversity trigger concomitant soil microbiome

changes in dryland ecosystems?: Journal of Applied Ecology 59: 560-573. DOI: https://doi.org/10.1111/1365-2664.14074

Grants and Contracts

- Theresa Laverty (PI), BRC-BIO: The interactive effects of bats and insects on shrub encroachment dynamics in the Chihuahuan Desert, National Science Foundation, $497,567, awarded, 7/1/2024 – 6/30/2027

- Niall Hanan (PI), Brandon Bestelmeyer (co-PI), Osvaldo Sala (co-PI), LTER: Long-Term Research at the Jornada Basin (LTER VII), National Science Foundation, $4,508,000, 12/1/2020 – 11/30/2025

- Western Sustainable Agriculture Research and Education Award, $304,450, grant is actively being used and goes through 2026.

- 2019-2025 "Novel Strategies to Increase Sustainability of Beef Production Systems in the Western United States". NIFA-AFRI-SAS #2019-69012-29853. Principal: Andrés F. Cibils et al.: *$ 8,937,554*.
- 2024–2025. Scientific Partnerships in Precision Ranching. DOE – BLM. PI: Utsumi, S.A.: $80,000.
- 2024-2027. Technologies to Enhance Climate-Smart Decision-Making in the Malpai Borderlands Group. NRCS-CIG #NR243A750011G035. PIs Utsumi S.A., Bestelmeyer B.T., Bakir M., Gifford C., Elias E., Winkler R., Moore C. $1,505,320.
- 2025-2028. Precision Ranching Knowledge Exchange Network: Building a Pathway for Successful, Climate-Smart Technology Adoption. USDA-NIFA A1721 # 2024-10224. PIs: Utsumi S., Elias E., Brunson M, Bestelmeyer B., Ward M: $ 999,716.

Outreach Activities

- Agrivoltaics Outreach: Participated in education outreach to highlight the potential agrivoltaics research at the CDRRC and the other selected array sites.
- "Going Batty at the Nature Park" (July 27, 2024): Theresa Laverty and undergraduate student Matt Becker (supported by an NSF REU) participated in public outreach event at the Chihuahuan Desert Nature Park. This evening event, organized by the Asombro Institute for Science Education, aimed to educate the community about local bat ecology and research. We set up interactive stations showcasing bat research tools and techniques, providing visitors with information on bat species found in our area of the Chihuahuan Desert. After sunset, PI Laverty led a guided bat walk using handheld ultrasonic detectors, allowing visitors to hear bats in flight. This outreach event successfully connected our research with the public, fostering an appreciation for local wildlife and promoting understanding of bat research being conducted at CDRRC and JER.
- Host Animal and Range Science students from Chico State University
- 2024 Chihuahuan Desert Rangeland Research Center Field Day
    - CDRRC Ranch Manager/Research Coordinator Andrew Cox presented regarding the use of virtual fencing.
- New Mexico State University Cooperative Extension Service
    - Southeast NM Ranchers' Workshop
    - Quay County Beef Production Workshop
- The Nature Conservancy/Indian Nations Conservation Alliance/Pueblo of Jemez
    - Returning Balance to Tribal Lands Workshop
- El Llano Estacado Resource, Conservation and Development Council
    - Northeastern New Mexico Prairie Partners Meeting
- Society for Range Management Annual Meeting
    - Virtual Fencing Workshop
- USDA Jornada Experimental Range and Bureau of Land Management
    - Advances in Precision Ranching and Virtual Fencing
- Host New Mexico FFA State CDE competitions
    - Pasture and Range
    - Land and Homesite

People

Cooperators and Collaborators

NMSU Animal and Range Sciences
USDA-ARS Jornada Experimental Range, Las Cruces, NM
USDA-Southwestern Climate Hub
Corta Madera Ranch, Pine Valley CA
The Nature Conservancy Dugout Ranch, Monticello, UT
Sunrise Ranch, Rodeo, NM
Diamond e Ranch, McNeal, AZ
Bureau of Land Management,
U.S. Forest Service
National Park Service
U.S. Bureau of Reclamation
University of Arizona Santa Rita Experimental Range
University of California-Riverside
Ute Mountain Ute Tribe
Navajo Nation
McDowell Sonoran Conservancy
Babbitt Ranches
Diablo Trust
NMSU UASNR Laboratory
Long Term Ecosystems Research (LTER)
Long Term Agroecosystems Research (LTAR)
USDA Southwest Climate Hub
Kansas State University
Texas A&M AgriLife Research
The Nature Conservancy Dugout Ranch
Evergreen Ranching
Rancho Corta Madera
Asombro Institute
BlueSTEM AgriLearning Center
NMSU Department of Extension Animal Sciences and Natural Resources
NMSU Klipsch School of Electrical and Computer Engineering
USDA-ARS Southwestern Cotton Ginning Research Laboratory
NMSU Fish, Wildlife and Conservation Ecology
Malapais Borderland Group

Jornada LTER

Ashley Asmus
Bob Schooley
Brandon Bestelmeyer
Curtis Monger
Dave Lightfoot
Dawn Browning
Deb Peters
Enrique Vivoni
Erica Rosenblum
Erik Lehnhoff
Greg Okin
Jennie McLaren
John Anderson
Kirsten Romig
Niall Hanan
Nicole Pietrasiak
Sarah McCord
Sheri Spiegal
Greg Cooper

Graduate Students

- Taylor Pichler – Fish, Wildlife and Conservation Ecology, MS
- Juliemar Cuevas-Hernandez - Fish, Wildlife and Conservation Ecology, MS
- Sara Campa Madrid – Animal and Range Sciences, MS
- Latifat Jimoh – Animal and Range Sciences, MS
- Andres Perea – Animal and Range Sciences, PhD
- Luis Ochoa – Animal and Range Sciences, MS
- Jake Van Sweden – Animal and Range Sciences

Post Doc.

- Mehmet Bakir, Post Doc.
- Maximiliano Spetter, Post Doc.

NMSU Faculty

- Santiago Utsumi
- Micah Funk

ASC Personnel

- Andrew Cox, Ranch Manager/ Research Coordinator
- Shad Cox, AES Livestock Operations Director