
CHIHUAHUAN DESERT RANGELAND RESEARCH CENTER
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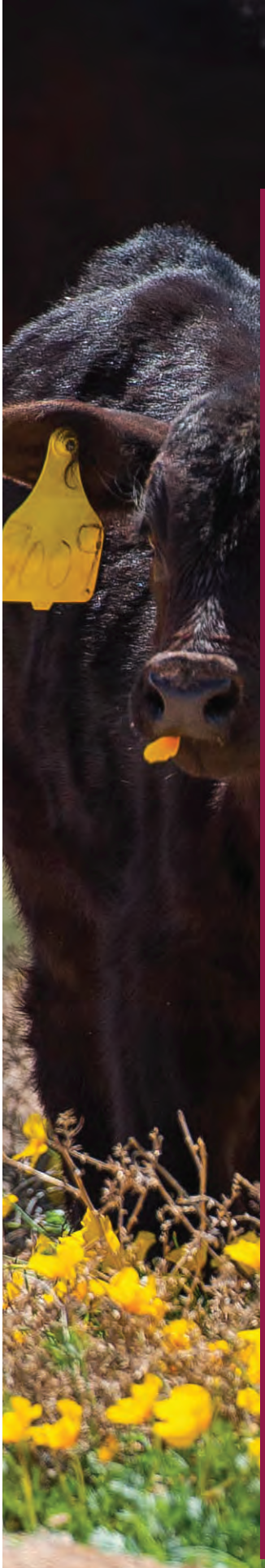
Conversion Table for English and Metric (SI) Units

The following conversion table is provided as an aid for those who may wish to convert data appearing in this report from English (U.S.) units to Metric (SI) units, or vice versa. (Calculations are approximations only.)

To convert English to Metric, multiply by	English (U.S.) units	Metric (SI) units	To convert Metric to English, multiply by
2.540	inches (in)	centimeters (cm)	0.394
0.305	feet (ft)	meters (m)	3.281
1.609	miles (miles)	kilometers (km)	0.621
0.093	square feet (ft2)	square meters (m2)	10.764
2.590	square miles (mile2)	square kilometers (km2)	0.386
0.405	acres (ac)	hectares (ha)	2.471
28.350	ounces (oz)	grams (g)	0.035
29.574	fluid ounces (fl oz)	milliliters (mL)	0.034
3.785	gallons (gal)	liters (L)	0.264
0.454	pounds (lbs)	kilograms (kg)	2.205
907.185	ton (2000 lbs) (t)	kilograms (kg)	0.001
0.907	ton (2000 lbs) (t)	metric tonnes (t) or Megagrams (Mg)	1.102
1.000	parts per million (ppm)	ppm (mg/kg)	1.000
1.121	pounds/acre (lbs/ac)	kilograms/hectare (kg/ha)	0.892
2.240	tons/acre (t/ac)	Megagrams/hectare (Mg/ha)	0.446
16.018	pounds per cubic feet (lbs/ft3)	kilograms per cubic meter (kg/m3)	0.062
0.070	cubic feet/acre (ft3/ac)	cubic meters/hectare (m3/ha)	14.291
73.078	ounces/acre (oz/ac)	milliliters/hectare (mL/ha)	0.014
62.710	bushels/acre (corn: 56# bu)	kilograms/hectare (kg/ha)	0.016
67.190	bushels/acre (wheat: 60# bu)	kilograms/hectare (kg/ha)	0.015
125.535	Cwt/acre (100 wt)	kilograms/hectare (kg/ha)	0.008
0.042	Langleys (Ly)	Megajoules (MJ)/m2	23.900
(°F-32)÷1.8	Fahrenheit (°F)	Celsius (°C)	(°C x 1.8) + 32

For additional helpful English-Metric conversions, see: https://www.extension.iastate.edu/agdm/wholefarm/html/c6-80.html and https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/null/?cid=stelprdb1043619



Executive Summary

The Chihuahuan Desert Rangeland Research Center (CDRRC) is in Doña Ana County, New Mexico, at the southern end of the Jornada Plain. Now divided by Interstate 25, the Center encompasses almost 100 square miles, with one-fourth of the land west of the Interstate. Land on the Center varies widely, with elevations from 4,000 ft. on the Rio Grande flood plain on the west side to 5,840 ft. at the top of Summerford Mountain in the Doña Ana Mountains on the east side. The nearly level plains of the north and central parts of the Center are on the Jornada del Muerto basin, with several small playa areas where water collects after rainfall. Soils range from sandy loams to clays overlying caliche hardpan.

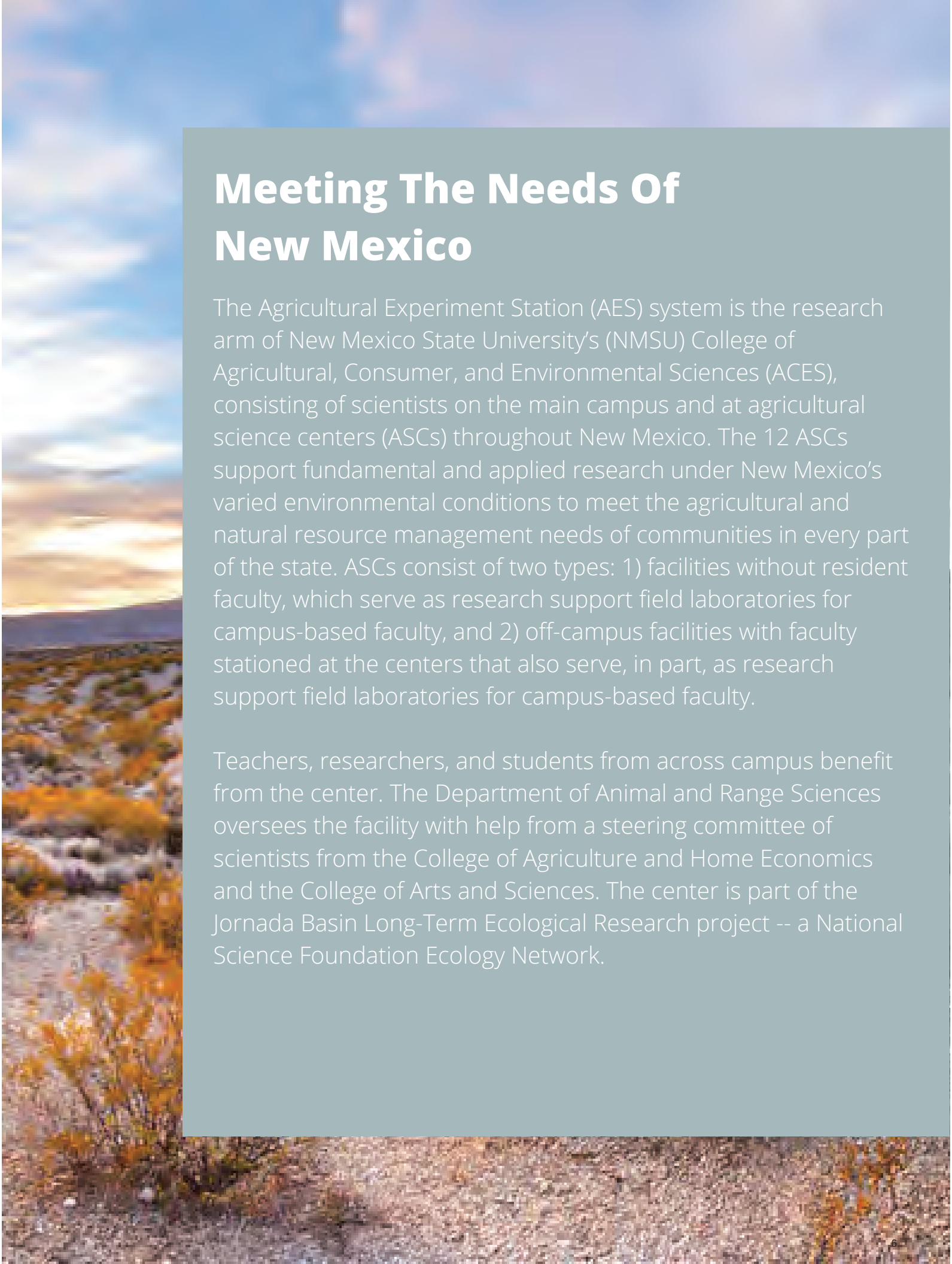
Several vegetation types occur at the center. Creosote bush dominates the upper slopes of the mountains and the hills along the river. At lower elevations, the creosote bush type grades into the mesquite type that grows on sandier soils, and into the tarbush type on heavier soils. The plains area, once dominated by black grama, today has been invaded by mesquite. These mesquite stands are interspersed with snakeweed and many species of grasses and forbs.

Wildlife populations on the Center are rich and varied. Among the larger mammals are mule deer, pronghorn antelope, gemsbok, bobcat, coyote, badger, and fox. Mountain lions have been sighted. There are also many rabbit and rodent species. Several bird species migrate throughout the area, but a large number also live and nest on the rangeland. Species such as roadrunners, hawks, and occasionally golden eagles are seen on the Center. Many lizard and snake species also inhabit these lands.

Although the COVID-19 pandemic restricted general access and activities on the CDRRC during 2020, approved research was conducted on CDRRC lands. This included rangeland cattle grazing studies and plant ecosystem restoration studies. Additionally, approved LTER-associated research continued at the base of Mt. Summerford, continuing long-term ecosystem studies, some of more than 30 years' duration. The LTER research was conducted by members of various NMSU departments and researchers from such other institutions as the University of New Mexico. The CDRRC also collaborated with research studies being conducted at the Corona Range and Livestock Research Center and the Clayton Livestock Research Center.

Mission

New Mexico State University operates the Chihuahuan Desert Rangeland Research Center (CDRRC) is to protect and ensure the availability of its resources for teaching, research, and extension endeavors that benefit the citizens of New Mexico as originally declared by Congress in 1927. The CDRRC conducts educational, demonstrative, and experimental development with livestock, grazing methods, and range forage, including investigation of the sustainability and management of natural resources and environmental ecosystems.



Meeting The Needs Of New Mexico

The Agricultural Experiment Station (AES) system is the research arm of New Mexico State University's (NMSU) College of Agricultural, Consumer, and Environmental Sciences (ACES), consisting of scientists on the main campus and at agricultural science centers (ASCs) throughout New Mexico. The 12 ASCs support fundamental and applied research under New Mexico's varied environmental conditions to meet the agricultural and natural resource management needs of communities in every part of the state. ASCs consist of two types: 1) facilities without resident faculty, which serve as research support field laboratories for campus-based faculty, and 2) off-campus facilities with faculty stationed at the centers that also serve, in part, as research support field laboratories for campus-based faculty.

Teachers, researchers, and students from across campus benefit from the center. The Department of Animal and Range Sciences oversees the facility with help from a steering committee of scientists from the College of Agriculture and Home Economics and the College of Arts and Sciences. The center is part of the Jornada Basin Long-Term Ecological Research project -- a National Science Foundation Ecology Network.

Current research efforts include:

• Evaluating continuous and seasonal grazing strategies at different intensities to determine effects on livestock performance as well as plant cover and composition.
• Evaluating performance of breeds of cattle concerning quality and quantity of forage in a hot, arid environment.
• Determining the influence of range conditions on wildlife populations.
• Autecology of plant species.
• Assessing competition and other interactions between common plant species.
• Ascertaining the role of small herbivores in a desert environment.

In addition to research conducted by the Department of Animal and Range Sciences, faculty and graduate students from other NMSU departments are conducting research at the Center. Currently, much of the research is in conjunction with the Long-Term Ecological Research program, which is part of a nationwide program funded by the National Science Foundation. The CDRRC is used for teaching, demonstration, and research projects with livestock, grazing methods, and range forage, including investigations into the sustainability and management of natural resources and environmental ecosystems. Due to its location and isolation, the CDRRC also is used by researchers from NMSU's Physical Science Laboratory (PSL), the U.S. Department of Defense, and private corporations for testing drones, telemetry, and radio interference.

Agricultural Experiment Station

What Is the Agricultural Experiment Station?

NMSU's Agricultural Experiment Station is the principal research unit of the College of Agricultural, Consumer and Environmental Sciences. All research faculty in the college have appointments in the Agricultural Experiment Station.

Mission

The Agricultural Experiment Station is not a physical site, but rather a system of scientists who work on facilities on the main campus in Las Cruces and at 12 agricultural science and research centers located throughout the state. The Agricultural Experiment Station system also interacts with other university research units and various state and federal agencies to provide opportunities for research that will benefit the citizens of New Mexico.

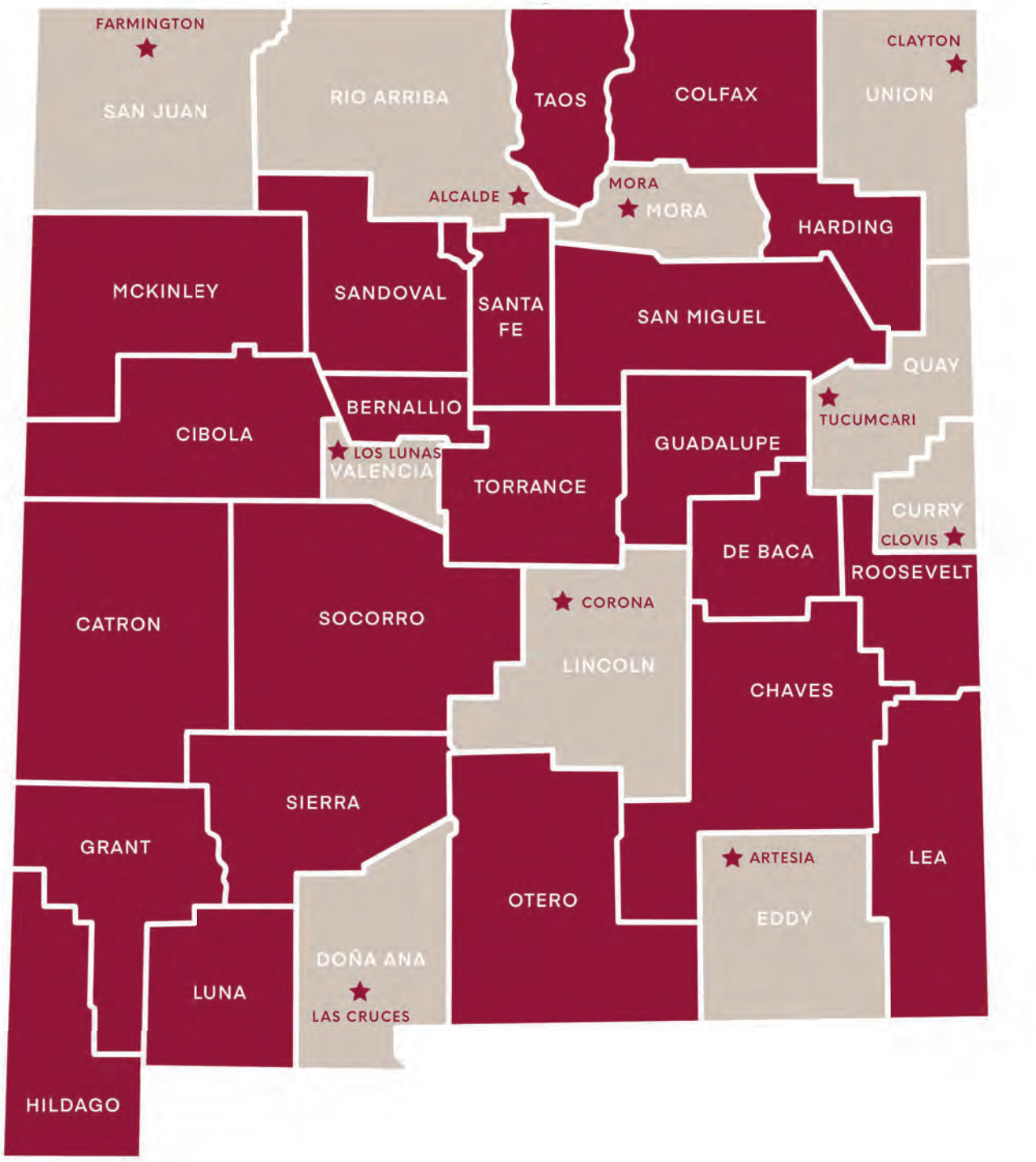
The Agricultural Experiment Station supports research designed to:

- Enhance agricultural profitability.
- Stimulate economic development using natural resources.
- Improve the quality, safety and reliability of food and fiber products.
- Sustain and protect the environment with ecologically sound practices.
- Manage and protect natural resources.
- Improve the quality of life for the people of New Mexico.

AES Research Focus includes, but is not limited to:

Agricultural water use efficiency, endangered/ sensitive species management, cattle genetics to improve grazing, improve forage quality, range management improved crop selection, soil-borne disease prevention, food safety and nutrition, product development and value-added agricultural products, medicinal plant uses, and water quality and treatment.

NMSU Agricultural Experiment Station



AES RESEARCH

NMSU's Agricultural Experiment Station research publications provide information to help improve production techniques and efficiencies for farmers, ranchers, dairies, and other agricultural producers.

Forestry

Agronomy

Dairy

Weather and Climate

Horticulture

Task Force Reports

Livestock and Range

Water

Economics

NOVEL STRATEGIES TO INCREASE THE SUSTAINABILITY OF BEEF PRODUCTION IN THE WESTERN UNITED STATES

Investigators: Andres F. Cibils, Animal and Range Sciences

Southwestern US rangelands are multi-use lands with strong ecological, economic, and social importance. In response to the effects of drought, land-use change, and other disturbances, restoration ecology is ranked among the most important fields in the coming century. Through local, national, and international collaborations our research group has undergone numerous multidisciplinary efforts to assess and identify best plant and soil restoration practices to guide rangeland restoration actions. Through peer-reviewed publications, and stakeholder, public, and practitioner communications, our work allows others to consider applicable restoration actions to address ACES critical issue pillars of Food & Fiber Production and Marketing, and Environmental stewardship.

Several reliable climate models now predict that the North American desert southwest will become hotter and drier, that variability in annual precipitation will increase, and that the onset of monsoon rains will occur later in the growing season. The viability of desert ranching enterprises will depend on their ability to adapt to these emerging conditions. An adaptation strategy that is gaining momentum among a growing number of ranchers in the SW United States involves raising drought-adapted indigenous low-input beef cattle biotypes. The Raramuri Criollo (RC) cattle from Chihuahua's Copper Canyon in Mexico is one such biotype that has exhibited intriguing foraging behavior traits. When compared to British crossbreeds, RC cows exhibit higher plasticity in habitat and diet selection; they appear to respond to forage scarcity by ranging farther and broadening the menu of plant species they include in their diets. This has led researchers to speculate that raising RC cattle could lower the environmental footprint of desert beef production because the impact of herbivory appears to be spread out across the landscape during drought periods when vegetation and soils are most vulnerable. This hypothesis, however, has never been formally tested.

Our goal is to investigate the effect of raising indigenous vs. introduced beef cattle breeds on long-term plant community dynamics in the Chihuahuan Desert. More broadly, our research addresses the fundamental question about whether innate differences in livestock foraging behavior are of any consequence to the structure and functioning of desert plant communities. The objective of this study will be to determine whether key Chihuahuan Desert soil and vegetation parameters respond differently to conservative stocking rates of Raramuri Criollo vs. Brangus cattle.

SOUTHWESTERN U.S. PLANT AND SOIL RANGELAND RESTORATION

Investigators: Akasha M. Faist, Animal and Range Sciences

Southwestern US rangelands are multi-use lands with strong ecological, economic, and social importance. In response to the effects of drought, land-use change, and other disturbances, restoration ecology is ranked among one of the most important current and future fields of focus. The significance is recognized as such, that the United Nations has declared 2021-2030 as the decade of ecosystem restoration. Ecological restoration is recognized as important for the maintenance of rangeland health, ecosystem function, and habitat quality. To effectively restore these systems and provide valuable ecosystem services we must identify mechanisms to overcome ecological constraints to restoration success.

While the need for effective restoration is realized, in arid and semi-arid systems there are multiple ecological constraints limiting success. Our research group examines these different constraints and identifies a way to overcome their limitations to improve rangeland restoration success. Communicating our findings through peer-reviewed scientific publications and direct presentations and conversations with stakeholders, we assess creative ecological restoration actions. Examples of our research efforts include identifying how soil seed banks can be used to enhance active restoration efforts as well as how restoring biotic communities living on the soil surface can augment plant growth across multiple southwestern deserts.

Through local, national, and international collaborations our research group has undergone numerous multidisciplinary efforts to identify the best plant and soil restoration practices to guide current rangeland restoration actions. Working closely with land management agencies our different findings have provided context to what native plants may be best to seed under different environmental conditions and how these seeds interact with the in-situ soil seed bank. Our research group has also worked with multiple academic institutions and agencies to develop a biological soil crust restoration manual used by practitioners, that contains current best restoration practices.

Providing effective restoration is broadly important in that it has the potential to benefit multiple ecosystem services. With nearly 70% of lands in the Western United States classified as rangelands, the services these multi-use lands provide are increasing in importance as stressors are also predicted to increase. Seemingly small actions such as identifying effective species to seed, or how to reduce soil erosion through ecological restoration actions can have large economic and social benefits. Identifying mechanisms for effective restoration actions to improve habitat quality can ultimately improve livestock production, which then can lead to helping local economies.

EFFECTS OF SUPPLEMENTAL FAT AND ROUGHAGE LEVEL ON INTAKE, GROWTH PERFORMANCE, AND IMMUNE FUNCTION OF NEWLY RECEIVED FEEDLOT CALVES

Investigators: Vinicius Nunes de Gouvea, Animal and Range Sciences & Clayton Livestock Research Center

RELEVANCE

What need is being addressed? Bovine respiratory disease (BRD) is a major cause of clinical disease and death in the feedlot industry, especially during the receiving period. Proper nutrition for newly received calves is important to recovery from stress associated with weaning, transportation, and the new feedlot environment. Decreasing the risk of developing BRD and the number of calves that require more than one treatment for BRD is likely to correlate well with increased dry matter intake after feedlot arrival. Nutritional practices, such as feeding different fatty acids, roughage levels, grain processing methods, and different feed additives could enhance immune response through increased energy intake, decreased inflammation, and oxidative stress.

RESPONSE

What is being done? Including fat in feedlot diets is an alternative to increasing the intake of energy. Since energy is the first limiting element for newly arrived feedlot cattle and activation of the immune system is an energy-dependent process, increasing the fat content in receiving diets could overcome the negative effects of low energy intake and improve immune function. However, information about sources and level of fat in receiving diets are scarce and variable and deserves further investigation, especially in low starch feedlot diets. The NMSU research objective was to evaluate the effects of dietary fat and roughage level on intake, growth performance, and immune function of newly received feedlot calves. Calves were started at the Chihuahuan Desert Rangeland Research Center near Las Cruces and transported to the Clayton Livestock Research Center.

RESULTS

What difference has been made/ what outcomes can be identified? Feeding low roughage diets [30% of diet dry matter (DM)] during the receiving feedlot period resulted in greater growth performance compared to high roughage diets (60% of diet DM). Supplemental fat (yellow grease at 3.5% of diet DM) increased the growth performance of newly received feedlot calves, however also increase the number of calves that required a second treatment for bovine respiratory disease (BRD).

PUBLIC VALUE STATEMENT

Why is this important? Who or what has been impacted? Feedlot receiving programs combining nutritional and management practices urgently need to increase animal health and to ensure a safe and adequate food supply. Beef cattle nutritionists should be able to adjust diet formulation to optimize immune response that will increase efficiency in the US feedlot beef industry. This project will generate results that have clear application to the improvident of animal health and growth performance. Researchers expect to demonstrate short-term opportunities for decreasing the incidence of BRD and reducing the economic risks associated with this disease.

GRAZING EFFECTS ON SOIL VARIABLES IN THE CHIHUAHUAN DESERT RANGELAND CENTER

Investigators: Carolina Brandani, Animal and Range Sciences & Clayton Livestock Research Center

Drylands are highly vulnerable to environmental pressures (e.g. scarcity of water, caused by low and highly variable precipitation, relatively high temperature, and intense solar radiation that result in low primary production). In the drylands of the southwestern United States aridity is forecasted to increase due to higher temperatures, more frequent droughts, and more erratic and lower precipitation. These climate impacts are projected to reduce the grazing capacity of rangelands. Over the last 52 years, nine severe droughts in the Chihuahuan Desert Rangeland (CDRRC), located in Las Cruces, NM, resulted in vegetation shifts, entailing an overall decrease of desirable/palatable species (black grama; Bouteloua eriopoda Torr.), and an estimated loss of 43% of grazing capacity based on perennial grass production. Such reductions in aboveground biomass can rapidly foster overuse of particular pasture resources if conservative management practices are not implemented. Such patchy overuse by cattle can exacerbate the vulnerability of these arid ecosystems, affecting negatively soil sustainability indicators. In this context Southwestern Beef Project (southwestbeef.org) has been evaluating grazing effects on soil health variables in the CDRRC comparing the historical grazed pastures (~30 years) with long-term grazing exclosure plots (4 to 80 years of exclusion) (Figure 1). Preliminary results showed that the long-term grazing exclusion decreased soil N concentration and soil N stocks at 0-10 cm of soil depth (-0.10 g kg-1 soil and -1.62 Mg kg-1; $P<0.05$), and did not affect soil C concentration and soil C stock ($p=0.63$ and $p=0.26$ respectively). Although the C/N ratio did not show the statistical difference ($P>0.21$) it was 2.4 times greater for ungrazed pastures compared to grazed pastures, which can be indicative of high recalcitrance of SOM in these areas. To better understand the dynamics of soil organic matter in desert rangelands the soil microbial community will be evaluated to compare the linkages among soil microbial diversity, N availability (NH4+ and NO3-), and labile C in grazed versus non-grazed rangeland pastures, verify if plant community directly drivers soil available N and labile C, and the influence of soil pH on the soil N and C mineralization in the Chihuahuan Desert rangeland.

The ecosystem integrity around watering points in the CDRRC will also be evaluated. This kind of study is usually called Piospheres, which describe herbivore utilization gradients around the watering point and are characterized as a spatially concentrated form of land degradation. Through radial symmetry established around watering points (Figure 2), as an ideal model, it is possible to evaluate the ecological impacts of grazing on the biotic and abiotic environment. This method has been used to investigate the interplay between grazing, vegetation, and the abiotic environment and can be used to guide range management regarding landscape functionality and rangeland productivity. This study will evaluate the grazing impacts around four drinkers distributed on pastures (14, 14, 4, and 5) at the CDRRC, which aims to describe plant species composition along grazing gradients f rom the watering point and assess the relationship between the plant species, soil redistribution, soil health variables, and distance from watering points.

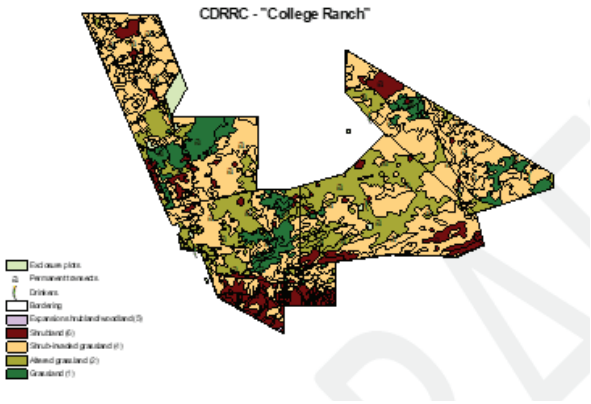


Figure 1: The CDRRC map where soil studies are being developed. The 40 permanent transects and the nine exclosure plots are distributed in the four pastures, which are characterized by five different ecological states.

Figure 2: The watering points/drinkers (stars) and the respective radial symmetries (concentric circles) on the pastures of the CDRRC.

SOIL STUDIES AT CLAYTON LIVESTOCK RESEARCH CENTER

Investigators: Carolina Brandani, Animal and Range Sciences & Clayton Livestock Research Center

CASE STUDY OF GRAZING IMPACT ON NATIVE AND IRRIGATED WHEAT PASTURES ON SOIL VARIABLES OF THE KIOWA NATIONAL GRASSLAND

Raramuri Criollo (RC) relative to conventional biotype can travel greater distances exploring larger areas of a pasture, spend more time grazing and traveling, especially during periods when forage is scarce or dormant. There is evidence that the adapted behavior of RC in arid conditions has allowed them to achieve better-distributed grazing pressure across the landscape (wider spatial distribution) rather than creating hotspots of intensive use that are frequently observed in conventional breeds. The better-distributed grazing pressure of specific pasture resources when grazed by RC than by conventional biotypes may result in positive effects on decreasing exacerbate grass losses, and as consequence decreasing the negative impacts on soil properties that are directly associated with the greater prone to land degradation, such as soil wind erosion and changes in soil organic carbon.

In this way, a study evaluating the foraging behavior of each breed (Raramuri Criollo and Brangus cows) using non-invasive animal wearable sensors that yield geolocation and activity data in real-time are being conducted at the pastures of the CLRC. The primary purpose of this study is to describe each breed's feeding site when offered the option to graze native rangeland vs. planted wheat pasture. However, it has also been an opportunity to investigate, as preliminary data, the use of data from GPS collars coupled to the cattle as a tool to identify the most visited areas (hotspots) in the pastures to evaluate soil grazing impacts. Grazing effects will be assessed by measuring soil health variables (soil chemical characterization and soil C and N), plant biomass, and the relationships between them, both outside of and within grazing hotspots areas – and comparing results between the hotspots and ungrazed/ or less visited/grazed locations. Moreover, the intensity of grazing use in the grazed portions (close/around hotspots) will be assessed using cattle location measured with GPS collars. Based on GPS data of the hotspots locations, the intensity of grazing (low, medium, and high) will be correlated with the soil variables and plant biomass.

SOCIAL STUDIES EVALUATING MANURE APPLICATION ON RANGELANDS

In New Mexico, manure disposal is a major challenge for the fast-growing dairy and beef industry. Interest in land application of organic amendments—such as biosolids, composts, and manures—is growing due to their potential to increase soil carbon and help mitigate climate change, as well as to support soil health and regenerative agriculture. While organic amendments are predominantly applied to croplands, their application is increasingly proposed on relatively arid rangelands that do not typically receive fertilizers or other inputs, creating unique concerns for outcomes such as soil properties, native plant diversity, and water quality. Application of beef manure to rangelands could serve as manure disposal from feedlots and soil amendment to improve soil characteristics and promote forage/herbaceous production in arid rangeland sites. Cabrera et al., 2009 evaluated the application of two doses of dairy manure on blue grama rangeland in New Mexico. They found that the recommended rate of 54 kg P ha-1 as a soil amendment was a promising practice to enhance rangeland soil and runoff properties and to dispose of unwanted manure. Application at this recommended rate did not promote increased runoff salinity, runoff P, soil salinity, or soil sodium. Another study evaluated 92 studies in a global meta-analysis, which had organic amendments added to arid, semiarid, or Mediterranean rangelands (Gravuer et al., 2019). On average, the authors found that organic amendments provide some environmental benefits such as increased soil carbon, soil water holding capacity, aboveground net primary productivity, and plant tissue nitrogen; and decreased runoff quantity. However, some environmental harms were also found such as increased concentrations of soil lead, runoff nitrate, and runoff phosphorus; and increased soil CO2 emissions. In this way, to maximize environmental benefits and minimize potential harms, this project intends to understand how soil and plant communities respond to beef manure amendments in arid rangelands. For this purpose, a long-term experiment will be set up in the native pastures of the CLRC (Figure 3). The studies will cover the following subjects: i) manure application to foster soil nutrient cycling on arid lands, ii) influence of manure application on litter (aboveground biomass) decomposition, iii) dynamic of soil organic matter on rangeland as the response of the manure application, and iv) effects of manure application on the dynamic of nutrient in the root system.

Figure 3: Beef manure long-term experimental plots in the native pastures of the CLRC.

IMPACT STATEMENT

Long-term grazing exclusion plots can provide valuable information regarding the impacts of historic grazing on the soils of the desert rangelands.

The identification of the phylum of the soil microbial community will inform about the soil nutrient cycling that prevails in the grazed vs un-grazed pastures of the CDRRC.

The use of data from GPS collars coupled to the cattle as a tool to identify the most visited areas (hotspots, overuse of specific pasture resource) in the pastures has the potential to be used to indicate areas with greater prone to land degradation which should be evaluated regarding negative impacts on soil properties.

Manure application on New Mexico rangelands can be a sustainable strategy to improve soil variables and increase forage production.

JORNADA BASIN LONG-TERM ECOLOGICAL RESEARCH (LTER)

In collaboration with the Jornada Experimental Range (USDA ARS), we have incorporated studies initiated in 1915 into the JRN LTER program. Previous research focused on desertification, a state change from perennial grasslands to woody plant dominance (i.e., desertified shrublands) that occurs globally. Based on findings from growing long-term databases, the breadth of studies was expanded to include four additional state changes that occur in dryland systems:

- a reversal form desertified shrublands to grassland states,
- transitions among different states dominated by woody plants,
- invasion by non-native grasses leading to novel states, and
- transitions to human-dominated states.

Processes of interest include water-mediated plant-soil feedbacks; patch-scale contagion by wind, water, and animals; landscape context; and time lags that are manifested as nonlinear dynamics and threshold behavior. These cross-scale interactions (the interactions between patterns and processes across scales) often lead to emergent behavior of broader scales that are not predicted from fine-scale patterns. Our study site is located in the northern Chihuahuan Desert, approximately 25 km northeast of Las Cruces, New Mexico, USA (+32.6 N, -106.7 W, elevation 1315 m). Annual precipitation is 24 cm and maximum temperatures average 13 C in January and 36 C in June. Our study site includes the 78,266 ha Jornada Experimental Range operated by the USDA Agricultural Research Service, and the 25,900 ha Chihuahuan Desert Rangeland Research Center (CDRRC) operated by New Mexico State University. The Jornada Basin LTER project was established in 1982 and is administered by New Mexico State University. This site is a member of the LTER Network, one of 25 long-term sites funded by the U.S. National Science Foundation. More information about the Jornada LTER and the research projects can be found at https://jornada.nmsu.edu/lter. Research listings can be found at https://lter.jornada.nmsu.edu/research/.

Chihuahuan Desert Rangeland Research Center

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