

Protecting Rangelands in a Changing Climate

Using a Heritage Cattle Breed to Maintain Ecosystem Function Under Livestock Production

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Heritage Genetics

What are heritage breeds?

When describing heritage breeds, it is helpful to think of a continuum from conventional domesticated breeds, such as Red Angus cattle, to wild animals, such as pronghorn antelope.

Conventional domesticated breeds have undergone extensive artificial selection, or breeding by humans, to exhibit desirable traits. As a result, these breeds are often tightly bound to human-provided resources such as water troughs and supplemental feed.

On the other side of the continuum are *wild animals*, which are generally not directly modified by human artificial selection and are more flexible in their movement and foraging patterns, responding opportunistically to changes in resource availability.

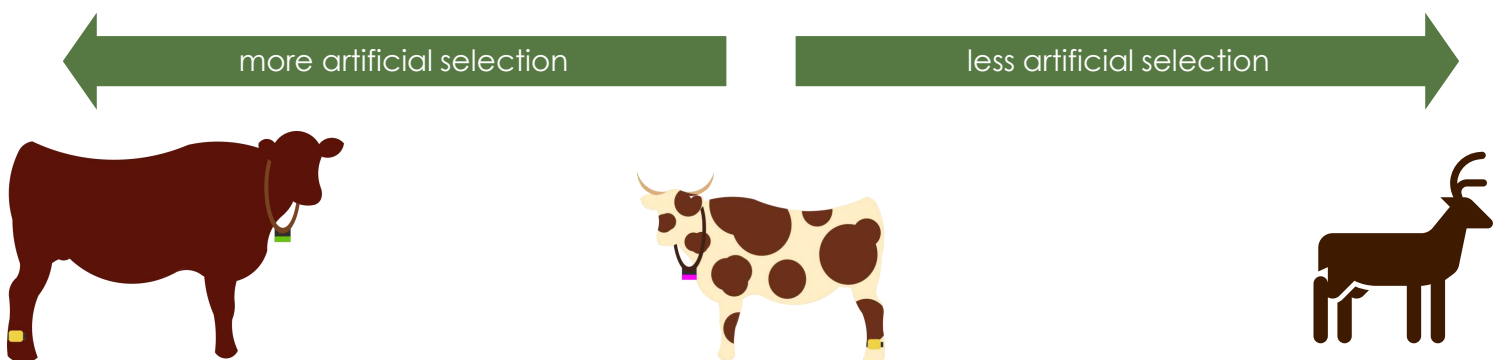
Heritage breeds fall somewhere in between these two categories. They are less modified by artificial selection than conventional domesticated breeds, with movement and foraging patterns that more closely resemble wild animals.

Rarámuri Criollo cattle

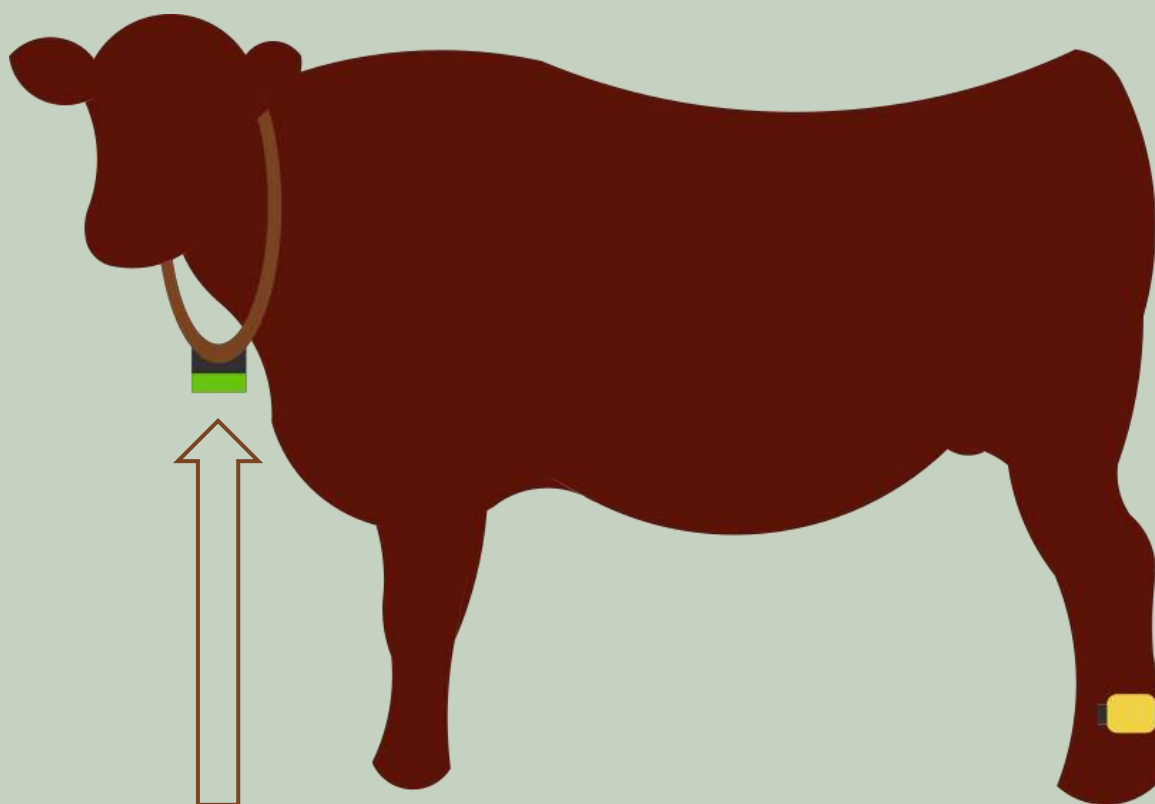
One heritage breed of particular interest is Rarámuri Criollo (referred to here as simply "Criollo"), a breed of cattle that was brought over from the Andalusia region of Spain in the late 15th Century and evolved to survive in the hot and dry conditions of the Mexican desert with very little human care or intervention.

Criollo have been studied in several arid and semi-arid ecosystems in North America, including the Jornada Experimental Range in New Mexico, and have been shown to have fewer hotspots of use, range over a larger proportion of their available landscape, and move farther from water compared to conventional beef cattle breeds.

Criollo cows are 300-600 pounds smaller than Red Angus cows, have horns, and tend to have mottled coats.



Landscape Use Patterns



GPS collars with 10-min fix rates provide detailed location data of 20 Angus and 20 Criollo cows.

Pedometers count steps and measure length and frequency of standing/laying bouts.

Landscape Use Patterns

Hypotheses:

H1: Criollo cows will increase use of forage from shrub-dominated sites relative to Angus cows. At the Jornada Experimental Range (JER) in New Mexico, Criollo cows were shown to have broader diets including more woody vegetation than conventional breed cows.

H2: Criollo will use more diverse, rugged, and far-from-water terrain than Angus cows. Also at the JER, Criollo cows were shown to exhibit these behaviors.

Why do we care?

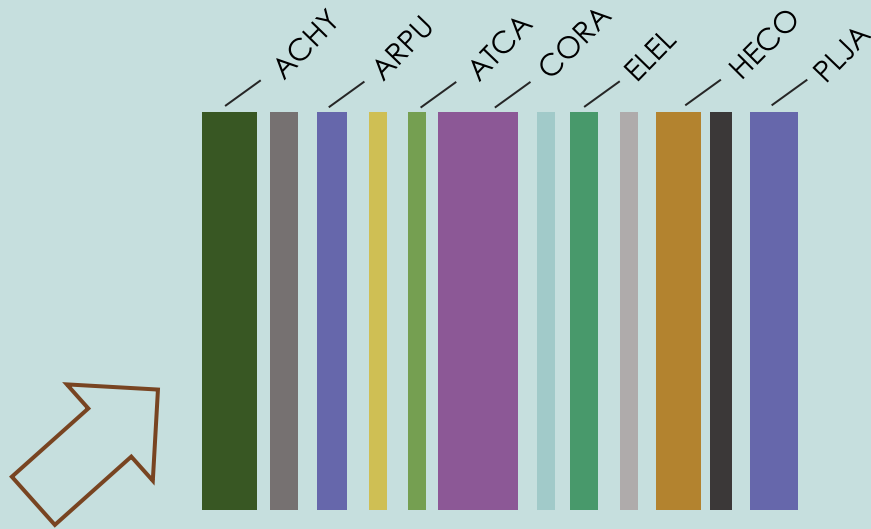
In tandem, these behaviors suggest that Criollo cows will have more diffuse space-use than Angus, which may translate to lower overall impact on ecosystem health and function.

What we're seeing so far:

Contrary to our expectations, we have found that Criollo cows are *more* attracted to grassy areas and *less* attracted to shrubby areas than are Angus cows. We have also found that Criollo cows are attracted to water and avoid steep terrain to a greater extent than do Angus cows, which also conflicts with our hypotheses (see table of HSF results below). These unexpected behaviors may be due to seasonal effects on behavior: previous work suggests that Criollo cows exhibit desirable behaviors (such as ranging farther from water, consuming more woody vegetation, etc.) more frequently in resource-limited seasons than in the growing season. All the data included in these analyses were obtained in Apr-May, when forage availability is high. We are curious to see what patterns arise in the data collected this fall (Nov-Dec).

	Est.	Std. Error	z value	Pr(> z)	Signif
Int	-11.131	0.153	-72.807	< 2e-16	***
Elev	-0.889	0.017	-51.694	< 2e-16	***
Slope	-1.510	0.029	-52.369	< 2e-16	***
log(dist_water)	0.089	0.007	12.473	< 2e-16	***
log(dist_salt)	-0.134	0.006	-23.812	< 2e-16	***
herb	0.195	0.008	25.185	< 2e-16	***
shrub	0.004	0.008	0.540	0.319	
drill_elev:BREEDCriollo	0.080	0.025	3.247	0.140	
slope:BREEDCriollo	-1.90	0.053	-35.715	< 2e-16	***
log_water:BREEDCriollo	-0.086	0.010	-8.971	< 2e-16	***
log_salt:BREEDCriollo	-0.149	0.008	-19.558	< 2e-16	***
herb:BREEDCriollo	0.220	0.011	19.498	< 2e-16	***
shrub:BREEDCriollo	-0.127	0.012	-10.675	< 2e-16	***

Ecosystem Services



Fecal DNA metabarcoding provides species-level identification of Criollo and Angus diets.

Soil health metrics include biocrust level of development scores, soil stability, and soil chlorophyll a concentrations.



Ecosystem Services

Hypotheses:

H1: Criollo cows will experience increased forage availability relative to Angus cows. By eating broader diets containing more woody vegetation than Angus, Criollo will effectively increase their amount of available forage. Furthermore, ranging farther from water and utilizing more rugged terrain will allow Criollo to forage over a larger portion of the landscape.

H2: Criollo cows will increase multiple metrics of soil health relative to Angus cows. By creating fewer hotspots of use and having an overall more diffuse space-use, Criollo cows will be less harmful to biological soil crusts, an important facet of soil health and stability in dryland landscapes.

Why do we care?

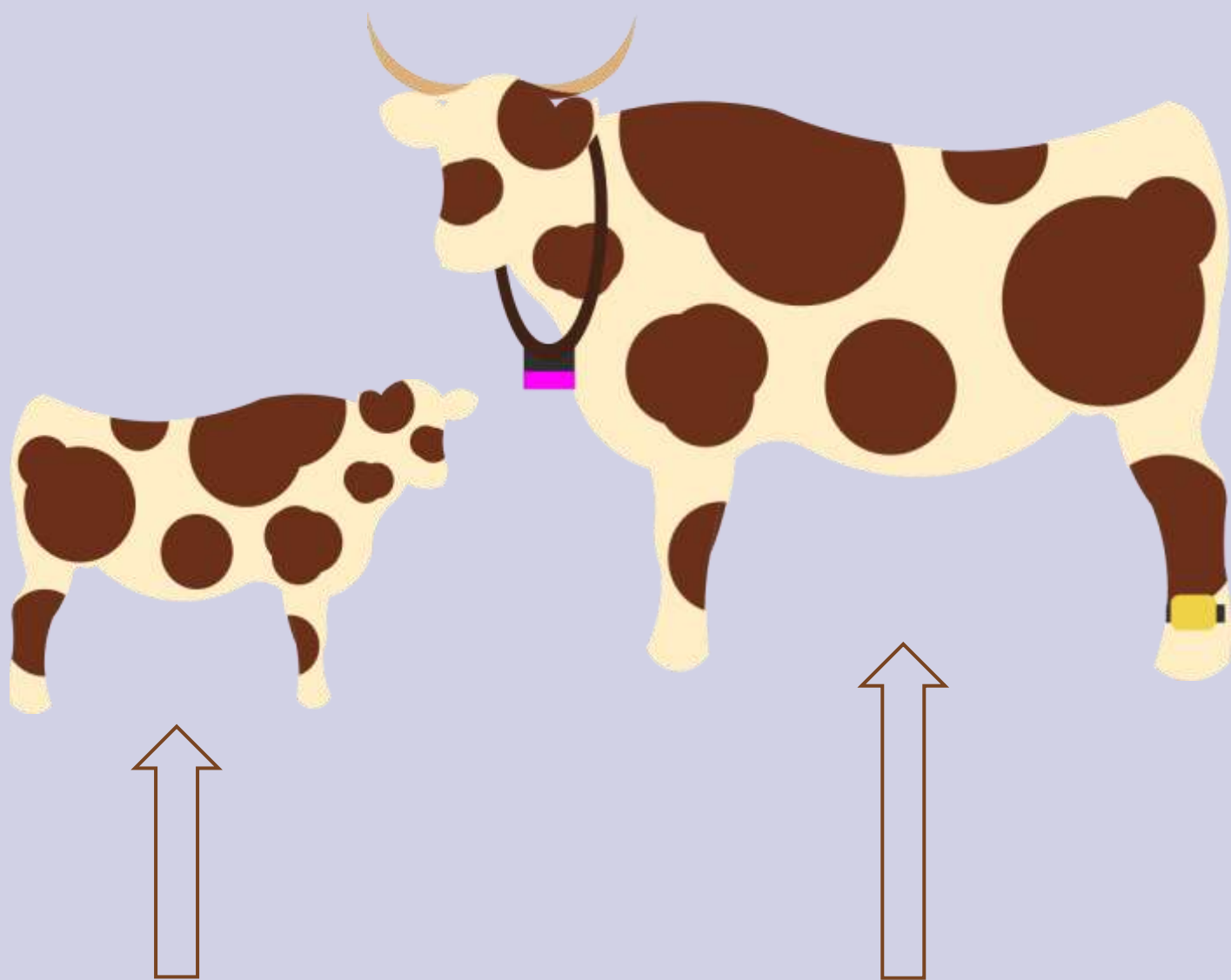
Livestock production is a culturally and economically important use of rangelands nation- and world-wide, and particularly so in the Colorado Plateau. However, the arid rangelands found in this region are fragile and are under threat from the effects of climate change. If livestock production continues without adapting to the changing climatic conditions, these rangelands may be damaged beyond repair, removing an important forage resource for native wildlife and domesticated livestock alike. It is essential that we find a way to preserve ecosystem function and the output of ecosystem services under livestock production to ensure a healthy future for these rangelands.

Current and future methods:

Forage availability: Every time the experimental herd enters and exits Drill Pasture, we collect fecal samples to send in for DNA analysis. This will tell us exactly which plants the Criollo and Angus cows are consuming. Paired with field surveys and remotely-sensed data, we will calculate the effective forage availability for each breed in Drill Pasture.

Soil health: We are collecting data on soil stability, biological soil crust level of development, and soil chlorophyll a concentrations across Drill Pasture to examine the effects of Angus vs Criollo grazing on soil health and stability.

Beef Production Metrics



Conception rates, calf and cow weaning weights, and calf survival rates are recorded for each breed every year.

Beef Production Metrics

Hypotheses:

H1-3: Criollo cows will have higher conception rates, wean more pounds of beef per kilogram of cow weight, and have higher calf survival than will Angus cows.

Pregnancy and lactation are extremely metabolically expensive. Because Criollo genetics are a better match for the arid rangelands of the Colorado Plateau, they will be more likely to be able to afford the metabolic costs of gestating and weaning a healthy calf.

Why do we care?

Even if Criollo cattle are less harmful to ecosystem health and function than conventional breeds of cattle, producers in the Colorado Plateau region are unlikely to incorporate heritage genetics into their herds if they are unlikely to turn a profit by doing so.

Current and future methods:

Every time the experimental herd enters and exits Drill Pasture, we record the weight and body condition score of each cow. This allows us to track cow performance on an individual basis through time. We will record calving rates each spring and will collect calf survival rates and weights at weaning each fall.



Future Directions

Heat tolerance

Cattle tend to congregate in desirable areas, such as those near water or shade and with preferred forage. This clustering can hasten rangeland degradation through increased soil erosion and decreased perennial grass cover, both of which lead to decreased weight gain in cattle.

Cattle are more likely to congregate in these desirable areas when experiencing heat stress, which will continue to occur more frequently in the face of a warming climate. Finding ways to reduce the prevalence of heat stress in cattle herds may help maintain ecosystem function and stability in desirable areas and therefore increase the overall health of the herd. Because Criollo cows are significantly (300-600 lbs) smaller than Angus cows and tend to have lighter coats than Angus cows, they may be less susceptible to heat stress.

In the future, we will investigate the effect of temperature on Criollo and Angus space-use with GPS- and thermometer-enabled collars that will allow us to track their movements through physical and thermal space. We will build resource selection functions to determine the effect of temperature on space use for each breed. We predict that Criollo cows will increase their use of areas close to water and woody vegetation at a higher temperature threshold than Angus cows.

Hybrid genetics

There are concerns regarding the compatibility of Criollo cattle with beef production in terms of calf weight gains and carcass size. Much of the equipment and machinery used in beef production is sized for conventional breeds, which are larger than Criollo.

Research from the Jornada Experimental Range suggests that a possible solution to this problem is to incorporate hybridization into a herd's genetics. Hybrid individuals (one parent Criollo, one parent conventional breed) tend to display the same desirable behavioral characteristics as Criollo cows but gain weight more quickly and reach a larger carcass weight. We will follow hybrid cows at the Dugout Ranch to determine if these behaviors also occur on the Colorado Plateau.

Suggested Reading

Anderson, D. M., Estell, R. E., Gonzalez, A. L., Cibils, A. F. & Torell, L. A. Criollo cattle: Heritage Genetics for Arid Landscapes. *Rangelands* **37**, 62–67 (2015).

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