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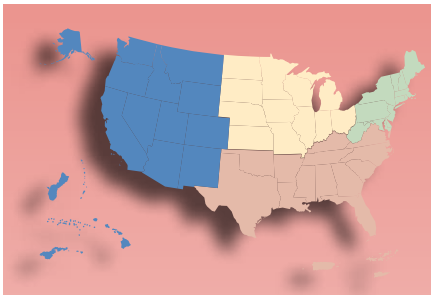

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Selecting Cattle to Improve Grazing Distribution Patterns, Rangeland Health and Water Quality

Geographic Adaptability: The western United States, especially on rugged terrain or extensive pastures.

Introduction

Livestock distribution is a critical concern for grazing lands. Rangeland health, the condition of riparian areas, water quality, fisheries habitat, and threatened and endangered species are all affected by uneven grazing patterns. Cattle typically graze heavily in areas with gentle terrain near water and avoid rugged terrain or areas far from water, often preferring riparian areas where they spend a disproportionate amount of time compared to uplands [1]. Yet concentrated grazing, especially in riparian zones, may reduce vegetative cover and increase soil erosion [2, 3]. Often, extensive and rugged pastures that experience problems associated with grazing have sufficient forage but suffer from adverse impacts to natural resources from localized heavy grazing. The key to resolving such problems is to encourage livestock to use pastures more extensively (e.g., farther from water and steeper terrain).

Most of the management approaches currently used to increase grazing uniformity, such as water developments and fencing, can help resolve livestock graz-

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ing distribution problems on both private and public lands. However, these practices usually require large capital expenditures. As a result, ranchers and land managers are often reluctant to develop water and build new fences. Less expensive solutions, such as salting away from water, usually do not sustainably alter cattle grazing patterns [4, 5]. New management techniques are needed that reduce the reliance on large capital expenditures and that embed desirable transgenerational distribution patterns within and across cattle herds.

A series of three SARE-funded projects (SW98-064, SW09-054 and SW15-015) provide the only research that we are aware of that has evaluated whether grazing distribution has the potential to be improved through genetic selection. These studies showed that selection for distribution has great promise and that additional research is warranted. However, there is a great deal more to learn and many questions still must be answered. Below are a few ideas that resulted from this research that may be useful to ranchers grazing extensive or rugged rangeland.

Management Implications

Selecting cattle with desirable grazing patterns and culling cattle with undesirable grazing patterns have been suggested as tools for improving distribution. One approach for such selection is to use breeds adapted to rugged and extensive rangelands. Research conducted as part of our first SARE-funded project (SW98-064) showed that cattle breeds developed in mountainous terrain utilize rugged rangeland more extensively than breeds developed in more gentle terrain. Ranchers in mountainous rangeland areas may be able to alleviate some of their grazing distribution problems by incorporating into their breeding programs breeds that evolved and were developed in rugged terrain, such as Tarentaise and Salers. To test this hypothesis, two breeds developed in different parts of Europe, as well as their crosses, were observed at the Thackeray Ranch in north central Montana. Tarentaise cattle developed in the French Alps consistently climbed higher and used higher elevations (greater vertical distance to water) than Herefords, which were developed in more gentle terrain in England [6]. Similarly, cows sired by Piedmontese and Charolais bulls were observed farther horizontally from water in foothill pastures than cows sired by Angus bulls [7]. Piedmontese cattle were developed in the foothills of the Italian Alps, while Angus cattle were developed in eastern Scotland. These differences in sire breeds are especially surprising considering that only half of the cow's genotype was contributed by the bull. In hot desert rangeland, ranchers may want to use breeds

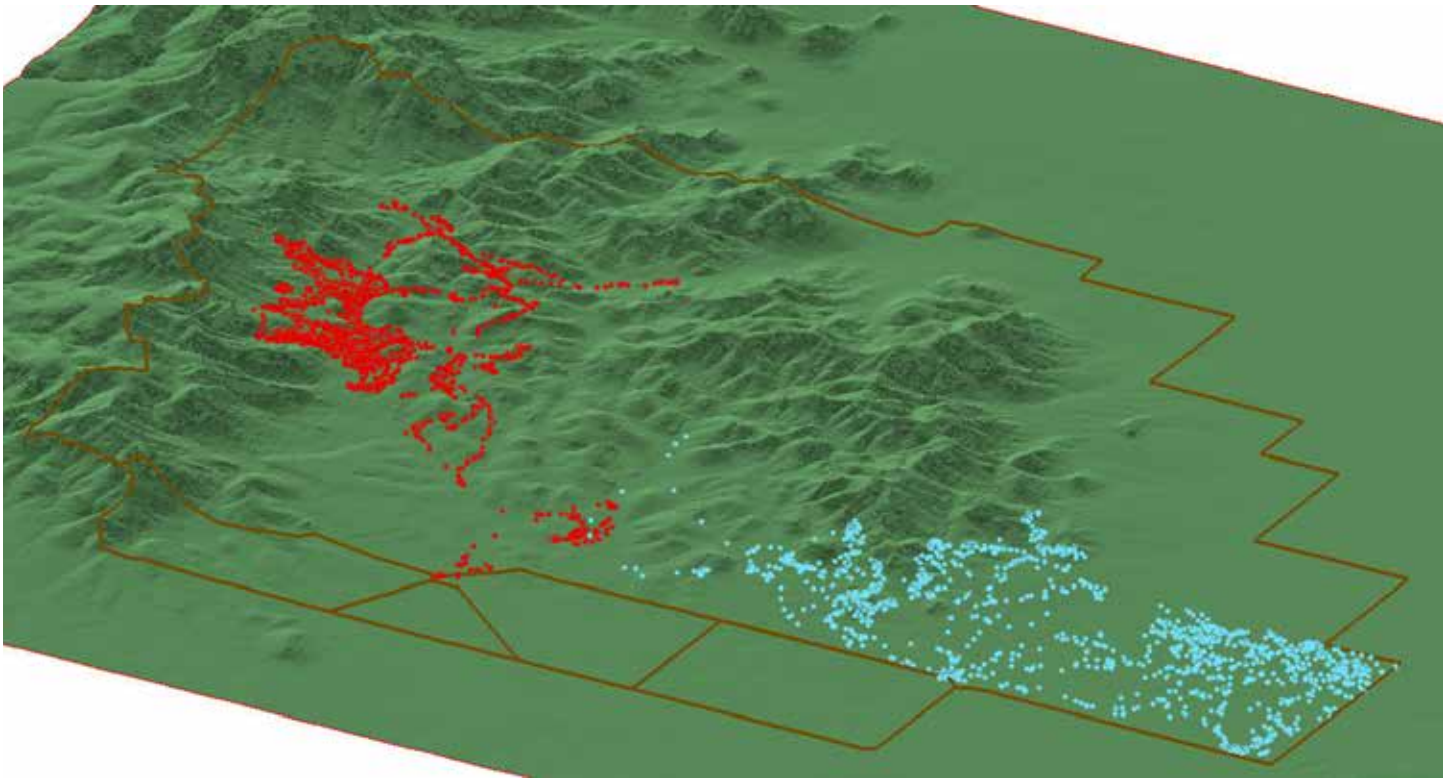

FIGURE 1. Example of the variation in grazing patterns of cows in the same pasture. These two Limousin cows were tracked from January to April 2011 in a 22,400-acre pasture at the Todd Ranch near Willcox, Ariz. The red locations indicate a Limousin "hill climber" while the blue locations indicate a Limousin "bottom dweller."

A cow tracked with a low-cost GPS collar at the Chihuahuan Desert Rangeland Research Center near Las Cruces, N.M.

with Brahman breeding so that the cattle are adapted to hot, dry climates and are more willing to travel far from water. Santa Gertrudis cattle, a Shorthorn and Brahman cross, walked farther than Herefords in southern New Mexico [8]. In another study in southern New Mexico, Brahman cows walked farther each day than Brangus or Angus cows; however, there was no advantage in use of areas far from water by any breed [9]. Brahman cows displayed a very winding (i.e., back and forth) grazing path than either Angus or Brangus cattle.

Other research has shown that calves learn where to graze from their mothers [10]. Anecdotal information suggests that problems may arise when cattle developed in gentle terrain or irrigated pastures are released into arid or rugged rangeland. In such situations, cattle may not venture far from water or up steep slopes. A study conducted in southern New Mexico showed that cows that were raised and remained in desert rangeland traveled farther from water than naïve cows from a sub-tropical area (east Texas) or cows that were raised in the desert but kept in east Texas for the three years before the study [11]. The management implication of this study was that when purchasing female replacements, producers should try to find animals that were raised in terrain and vegetation that is similar to what they will be grazing.

Individual cows within a herd can have very different grazing patterns (Figure 1). Culling or removing cows that prefer bottoms and riparian areas and spend a disproportionate amount of time in sensitive rangeland can potentially increase uniformity and the sustainability of grazing. The problem with this approach is accurately identifying cows with undesirable grazing patterns and determining how many cows should be culled.

The best time to observe cattle to categorize their grazing patterns as desirable or undesirable is when animals are first released into a pasture. Observations also should be collected during the early morning when cows begin grazing (e.g., 6–9 am). Cattle typically graze for two periods (or bouts) each day, during the morning and evening. At midday, cows are often resting near water, especially during the summer. Research conducted during our first SARE project showed that a cow's location during the early morning was a good indicator of where she would spend the majority of her time grazing during that morning's grazing bout, as well as where she had grazed during the previous evening's grazing period [12]. Cattle grazing patterns also can vary greatly from day to day, so several observations are needed to get an accurate estimate of a cow's grazing patterns. In our latest SARE project, GPS tracking data collected over a three-month period were evaluated, and data from one-, two- or three-month intervals were compared. These analyses suggest that two-month tracking periods are equivalent to three-month tracking periods for identifying differences in terrain-use among beef cows. In our first SARE project, we observed cows in multiple pastures and recorded their location at least 10 times in each pasture. That study supported that when cows are observed on multiple occasions in bottoms or riparian areas during the early morning shortly after being turned into a pasture (first third or first half), it is likely that their grazing patterns may be undesirable and they could be considered for culling.

Implications for Riparian Area Management

In our first SARE study, stubble heights of grasses and sedges in riparian areas were 5 inches in pastures grazed by hill climbing cows and only 3 inches in pastures grazed by bottom dwelling cows [13]. The differences in grass and sedge stubble heights observed between these treatments would be economically important for many public land ranchers. A standard for grazing on riparian areas is often forage stubble height of 4–5 inches [14]. If stubble heights fall below the standard, livestock are often required to be moved to a new pasture or off the allotment. In our first SARE study [13], pastures grazed by hill climbers had acceptable grazing levels based on this standard, while grazing levels in pastures grazed by bottom dwellers were not acceptable. Forage utilization measurements on upland slopes also suggested that hill climbers used rough terrain more extensively than bottom dwellers. Forage utilization in pastures grazed by hill climbers was affected less by slope, horizontal distance to water and vertical distance to water than pastures grazed by bottom dwellers. These results demonstrate that selection for grazing distribution has the potential to improve conditions of riparian areas and other sensitive areas that have

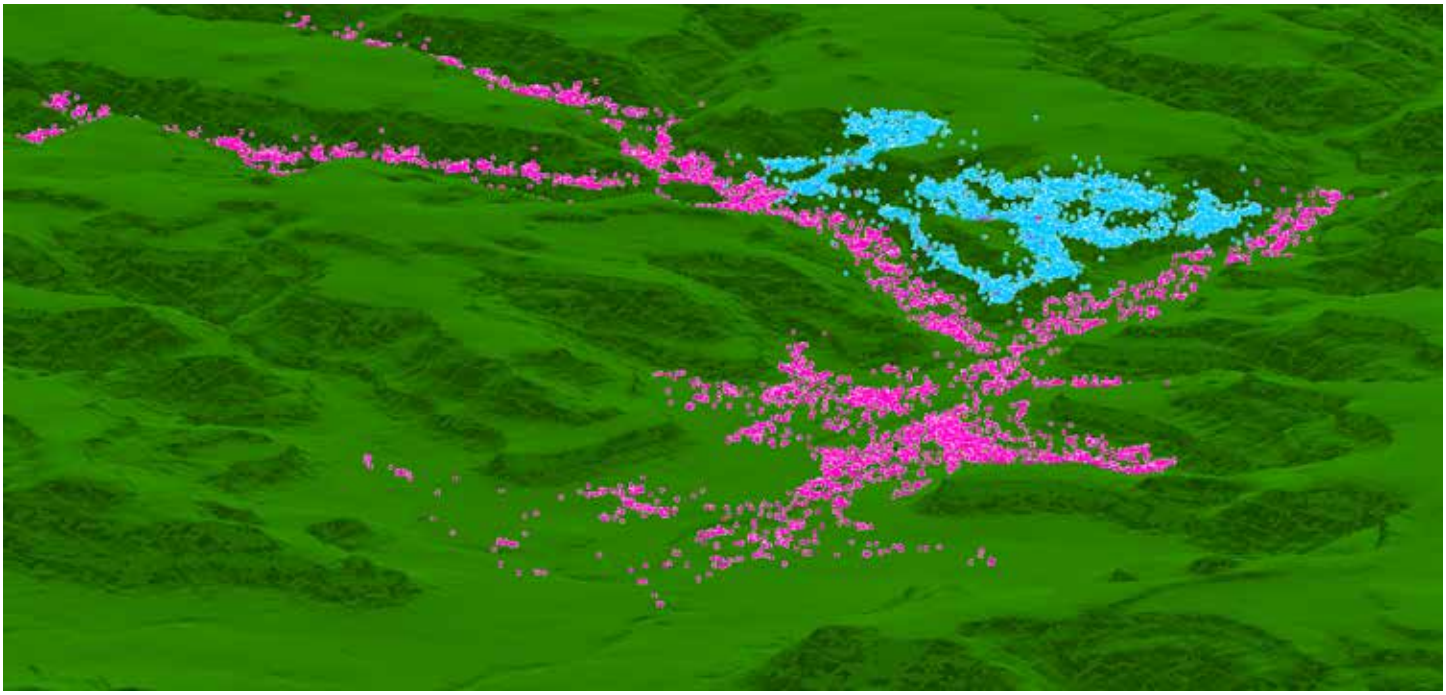

FIGURE 2. (Above) Grazing patterns of two "black baldy" yearling heifers in a 2,600-acre pasture at the Hartley Ranch located near Roy, N.M., from November 2009 to April 2010. Heifers had different genotypes for candidate gene associated with terrain use (glutamate receptor 5) that accounted for 24% of the phenotypic variation in use of steep slopes and high elevations [15]. The blue locations indicate a black baldy "hill climber" while the pink locations indicate a black baldy "bottom dweller." (Right) A landscape view of the Hartley Ranch.

been heavily grazed in the past, and to increase the use of upland slopes that previously received little grazing.

The impact of selection for distribution on performance of the herd is an important consideration for ranchers. Research conducted in our first SARE project [6, 7] found that the location where cows grazed was not related to their pregnancy rates, weight or body condition score. In addition, cattle that used high and steep terrain had similar calf weaning weights to cows that remained in gentle terrain near water. Thus, our past research findings strongly suggest that selection of animals that spend more time on high upland slopes and culling cows that graze in lower terrain near water would have no adverse impacts on any conventional production metrics, including calf growth, cow body weight or condition, or pregnancy rates. Furthermore, our more recent research findings support that genetic selection for animals with more dispersed grazing patterns would over time create herds that have fewer environmental impacts on riparian areas and other critical habitats.

SARE Research Synopsis

The objectives of the second and third SARE projects (SW09-054 and SW15-015) were to identify and validate genetic markers that were associated with terrain use in beef cows grazing mountainous and extensive rangeland pastures. Genetic markers that are associated with phenotypic traits are often referred to as quantitative trait loci (QTL). The presence of QTL for terrain use would indicate that grazing distribution is inherited and that genetic selection could be effective.

Methodology

Cattle were tracked at 14 ranches located in New Mexico, Arizona, Colorado, Nevada and Wyoming. At each ranch, 8–35 cows were tracked with global positioning system (GPS) collars at 10- or 15-minute intervals for periods of 3–19 weeks. Cow breeds varied across ranches, but the majority were Angus or Angus crosses. Cows were tracked during the

Collecting blood for DNA analyses.

summer, fall, winter and spring seasons. At some ranches, cows were lactating and had calves, and at other ranches cows were dry. Blood samples were obtained for all tracked cows to use for DNA analyses. Most of the cows (89%) were genotyped using the Illumina BovineHD SNP array, which evaluates approximately 770,000 genetic markers (i.e., single nucleotide polymorphisms, or SNP) across the 30 bovine chromosomes. The remaining cows were genotyped using the BovineSNP50 BeadChip (53,714 SNP). In total, 330 cows were tracked, genotyped and used in the analyses.

In our earlier study (SW09-054), genetic markers associated with terrain use were identified with single SNP regression [15], which may result in more false positives than the BayesC methodology. The BayesC methodology was not available at the time of our previous study. In our latest study (SW15-05), a genome-wide association study was conducted using the BayesC methodology, which is the software now used by most breed associations for genetic evaluation. Our latest genome-wide associate study also had over 3.5 times more cows than the previous study [15].

The statistical model accounted for the ranch, season, lactation status, breed and terrain type by using the start of tracking to identify contemporary groups. Analyses were designed to identify individual genetic markers known as SNP that were associated with terrain use phenotypic traits. Important SNP were identified for each phenotypic terrain use trait and were termed as QTL or candidate SNP. Even though important SNP were identified, it was obvious that grazing distribution traits are affected by many regions of the chromosome, so we determined these are polygenic traits. This means that for future studies we need to conduct whole-genome methodologies for genetic improvement strategies, similar to most of the traits that currently have genome-assisted expected progeny difference (EPD).

Summary and Application

In the second study [15], five genetic markers (SNP) accounted for 36% of the variation in a terrain use index of slope and elevation use (Figure 2). In the last (third) study, a total of 29 putative candidate genes were identified for terrain use in beef cattle. The association of genetic markers with the use of steep slopes, high elevation and areas far from water shows that terrain use can be inherited. The large number of candidate genes demonstrates the polygenic nature of terrain use traits. The functional annotation analysis showed that these candidate genes were related to a variety of biological processes including hypoxia, feed efficiency and weight gain.

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Although these findings are exciting, the association of the genetic markers and terrain use in these studies was not yet sufficient to develop a commercially viable genomic breeding value for terrain use. However, our results demonstrate the potential to develop a breeding value that ranchers could use to rank bulls and replacement heifers for their potential to produce daughters that are willing to use rugged terrain and travel further from water. Detection of genotype to phenotype associations in the latest study was likely limited by the moderate sample size and heterogeneity in some of our data points, which is inherent in large-scale field studies. Terrain, vegetation, breeds and management varied across the 14 ranches used in the study. Therefore, a large independent population of beef cows, composed of one breed, grazing on the same pastures is needed to refine terrain-use measurements and further elucidate the role of genetics in cattle grazing distribution on rugged rangeland.

With additional research and development, ranchers may be able to identify bulls and replacement heifers that have desirable breeding values for terrain use using only DNA samples from hair or blood. In addition, the cost of GPS tracking is dropping due to technological advancements. Currently, ranchers may be able to identify cows that use steeper terrain and areas far from water using GPS tracking and visual observations. Although more research is needed, selecting for such "hill climbing" cows may improve use of rugged rangeland and may reduce grazing impacts on riparian areas.

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