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Evaluating New Approaches to Improve Livestock Grazing Distribution Using GPS and GIS Technology

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ABSTRACT. Uneven distribution results in many of the natural resource concerns associated with livestock grazing in extensive rangeland pastures. Cattle may heavily graze portions a pasture (e.g., bottoms or riparian areas) while abundant palatable forage exists on upland slopes. With the help of Global Positioning System (GPS) and Geographical Information System (GIS) technology, livestock grazing behavior and management can be evaluated with greater resolution. Movement patterns of cattle are recorded GPS tracking collars and used to compare grazing management treatments. These GPS collars are accurate within 6 to 11 yards (5 to 10 m) and record cattle locations on a 24-hour basis for long periods (days to weeks). The goal of this research is to develop practical techniques that ranchers and land managers can use to increase uniformity of grazing and improve the stewardship of western rangelands. Two approaches for improving grazing distribution are currently being examined. In the first study, the potential of selecting cattle for improved grazing distribution is being evaluated. A cattle breed developed in the French Alps (Tarentaise) used rugged foothill rangeland more evenly than a breed developed in more gentle terrain of England (Hereford). This suggests that grazing distribution can be improved by using cattle breeds that were developed in mountainous terrain. Grazing patterns of individual animals within a breed also vary. Cattle were observed and separated into two groups (hill climbers and bottom dwellers) based on their previous grazing patterns. Hill climbers used steeper slopes and higher elevations and bottom dwellers used gentler slopes near water. These groups are being observed in similar, but separate, pastures. Forage utilization and movement patterns of being compared in a 3-year study. If uniformity of grazing is greater in pastures grazed by hill climbers than in pastures grazed by bottom dwellers, ranchers may be able to select cattle that grazed rugged rangelands more evenly and minimize resource degradation associated with concentrated grazing in localized areas. In the second study, highly palatable supplement was placed in steep rugged terrain to lure cattle to underutilized rangeland. Observed livestock grazing patterns and forage measurements showed that grazing use increased in areas within 660 yards (600 m) of supplement. In similar terrain where supplement was not placed (control), grazing use by cattle was minimal. Strategic placement of low-moisture molasses supplement should allow land managers to modify cattle grazing patterns and help alleviate resource concerns associated with uneven grazing.

INTRODUCTION

Many of the resource concerns associated with overgrazing by livestock are the result of uneven grazing distribution. On extensive rangeland pastures, cattle may graze areas with gentle terrain near water more heavily than rugged terrain or areas far from water (Valentine, 1947; Cook, 1966). Cattle often prefer riparian areas and spend a disproportionate amount of time in these areas as compared to uplands (Smith et al., 1992). Concentrated grazing on uplands and especially in riparian zones may reduce vegetative

cover, water infiltration and streambank stability and increase soil erosion (Blackburn, 1984; Kauffman et al., 1983). Livestock producers and land managers must consider the spatial variation in grazing to adequately evaluate the impacts of grazing by livestock and other herbivores (Coughenour 1991), and to determine the appropriate management actions to remedy the associated resource concerns.

Most of the management approaches currently used to increase uniformity of grazing have been know for over 40 years (Skovlin, 1957). Water developments, herding, salting, and fencing have been used successfully to improve livestock grazing distribution on both private and public lands. However, water developments and fencing usually require large capital investments. Managers often have difficulty predicting the effects of these range improvements on livestock distribution, which prevents them from making an adequate cost-benefit analysis. As a result, managers are reluctant to develop water and build new fences. Other approaches to improve distribution such as herding require additional labor. Predictive simulation models could help managers determine if established management practices (e.g., water development and herding) would be cost effective in their situations (Bailey et al., 1996).

Innovative and cost-effective approaches to improve livestock grazing distribution are needed. Choosing animals that are more willing to graze further from water, graze steeper slopes and higher elevations may be an effective approach to reduce uneven grazing that is often observed in large, rugged pastures. Managers also may be able to lure cattle to undergrazed rangeland. Dehydrated molasses supplements are highly palatable and easy to transport. If managers place the supplement in rugged terrain and in areas far from water, cattle may travel to the placement site and graze nearby areas that otherwise would be rarely used. The objective of this paper is describe how Global Positioning System (GPS) and Geographical Information System (GIS) technology are being used to evaluate the potential for selecting cattle of improved distribution and to verify if cattle can be lured to under utilized rangeland with dehydrated molasses supplement.

GPS AND GIS TECHNOLOGY

Animals can be tracked on a 24-hour basis using GPS receivers incorporated into collars. At our research site in northern Montana, Lotek GPS 2000 collars (Lotek Engineering Inc., Newmarket, Ontario) have been used to track cattle during the summer, fall and winter. These collars can be differentially corrected (Moen et al., 1997) so that the accuracy of location fixes is within 6 to l1 yards (5 to 10 m). Without differential correction, accuracy is within 20 to 40 yards (roughly 20 to 35 m). Location fixes can be recorded at intervals of every 5 minutes to every 6 hours. Collars can also record ambient temperature and number of vertical and horizontal head movements. Head movements can be used grazing time and differentiate animal activity (resting or grazing) between location fixes (Udal et al., 1999). Location and other data are stored in the collar, and animals must be caught and the collar removed to retrieve the data. Disposable or rechargeable batteries can power collars. Disposable batteries often provide sufficient power to obtain over 3000 locations. Existing rechargeable batteries provided sufficient power for 500 to 1000 locations, but new rechargeable batteries are being developed that should provide power for 1000 to 3000 locations.

Geographical information system technology provides powerful tools to analyze and summarize the data collected from the GPS collars. Digital elevation maps can be used as base maps. Pastures used in our study were mapped using a backpack L-band GPS receiver with an accuracy of 1.1 yards (1 m). Maps and analyses were conducted using ArcView® (ESRI, Redlands, CA). The ArcView® Spatial Analyst and Tracking Analyst were used extensively. This GPS (collars) and GIS technology has become an integral component of our livestock grazing distribution research program.

SELECTION FOR IMPROVED GRAZING DISTRIBUTION

Breed Selection

Livestock producers and land managers may be able to improve uniformity of grazing by selecting breeds that were developed in more rugged terrain. Tarentaise cattle developed in the French Alps consistently climbed higher and used higher elevations (greater vertical distance to water) than Herefords on northern Montana rangeland (Bailey et al., submitted). In one of the two years of this study Tarentaise used steeper slopes than Herefords. There were no differences among breeds in use of slopes during the other year of the study. Ongoing research is comparing terrain use of cows sired by Angus, Charolais, Piedmontese and Salers bulls. Although the differences are not statistically significant, cows sired by Piedmontese and Salers bulls tended to use more rugged terrain than cows sired by Angus bulls. Piedmontese and Salers cattle were developed in mountainous regions of Italy and France, respectively. Areas of northeastern Scotland where Angus cattle were developed also contained rugged terrain. Although breeds may differ in terrain use when they are grazed together in the same pasture, additional research is needed to verify that overall herd grazing patterns. Social interactions may overwhelm any differences in terrain use resulting genetic factors such as breed (Mosley, 1999)

Individual Animal Selection

Selecting livestock based on their grazing patterns and terrain use has the potential for improving livestock grazing distribution (Roath and Kruegar, 1982; Howery et al., 1996). If animals have preferences for certain areas of pastures or types of terrain, uniformity of grazing could be improved by choosing animals that prefer upland slopes, higher elevations and distances further from water and culling animals that graze near water, or other areas that usually are overgrazed. For selection to be effective, there must be significant individual variation in terrain use and terrain use must be a heritable trait. In addition, selecting or culling cows based on their grazing patterns must not adversely affect performance of the herd (i.e., weaning weights and pregnancy rates).

<u>Individual Animal Variation in Terrain Use</u>

In foothill pastures in northern Montana, observers on horseback have observed the locations of individual cattle two to three times per week for four consecutive years (1997 to 2000). Large variations in terrain use have been observed. For example, average slope use by cows in one pasture varied from 10 to 28%. These horseback observations have been verified and expanded by the use of the GPS tracking collars. Based on the horseback observations collected in 1997, cows that used the steepest and highest terrain (hill climbers, n=4) and cows that used the lowest elevations and gentlest slopes (bottom dwellers, n=5) were identified, and collars were placed on these animals during late August and early September in 1998. Figure 1 show an example of the large variation in grazing patterns that can exist between individual animals.

Most of the horseback observations were collected in the early morning usually between 6:30 to 8:30 am. To ensure that this was an appropriate time to determine where cattle graze, data from the 9 cows collared in August and September 1998 were analyzed to evaluate how well early morning observation reflected where cattle grazed. Cows usually went to water between 9:00 and 11:30 am and left water at 5:00 to 7:00 pm. During this interval, cattle usually remained near water (< 220 yards or 200 m). Areas near water had been heavily grazed before collars were placed on the cows, and there was little opportunity for grazing near water. After leaving water in the evening, cattle generally traveled to an area where they would stay until they walked to water again on the following morning. From the period one hour after leaving water until one hour before traveling to water, 74 to 86% of the observations were within 440

yards (400 m) of their location at 7 am (when horseback observers usually recorded locations). Thus, the 7 am observation was indicative where the cow generally grazed.

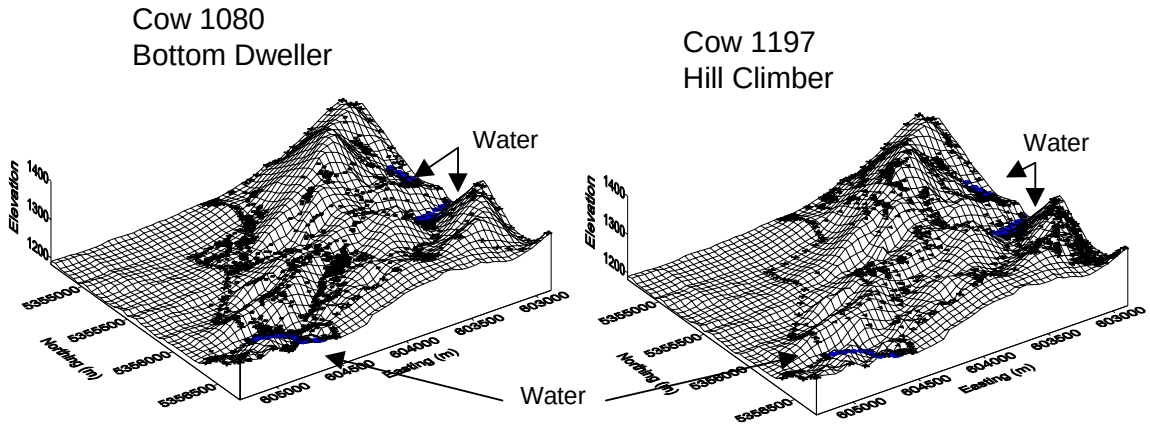

Figure 1. Locations of a cow (1080) identified as a bottom dweller (7-year old Hereford) and a cow (1179) identified as a hill climber (7-year old Tarentaise). Cows were in the same 833-acre (337-ha) pasture with 158 other cows. Locations were recorded every 10 minutes during the day and every 20 minutes at night during late August and early September 1998.

Heritability

Heritability of terrain use has not yet been determined, although several related observations indicate that these traits may be heritable. First, differences among cattle breeds in terrain use in Montana (Herefords vs. Tarentaise) suggest that variation in these traits may be at least partially explained by genetic factors. Use of terrain by individual cows was relatively consistent for 2 years in the Montana study with repeatabilities of 21% and 37% for use of slopes and vertical distance traveled from water. Repeatability is the upper limit of heritability (Falconer, 1960, p. 160-211), and the results show terrain use has the potential to be heritable. Based on additional observations from Montana, terrain use of daughters was not related to terrain use of their dams at 2 years of age, but at 3 years of age terrain use of daughters and dams may be related (Bailey et al., 2001). These preliminary analyses (regressions of offspring on dam) also indicate that terrain use may be heritable.

Relationship of Terrain Use to Performance Traits

The relationship between performance traits and observed grazing patterns of cows grazing Montana foothill rangeland was also examined (Bailey et al., submitted). Attributes of the cow such as weight, hip height and body condition score were not consistently related to terrain use. Weaning weight of their calves and calving date were also not consistently related terrain use. Grazing patterns of pregnant and non-pregnant cows were also similar which suggests that reproductive performance may not be related to terrain use. Data collected in this study indicate that culling cows based on terrain use should have no adverse effect on overall performance of the herd.

STRATEGIC SUPPLEMENTION

Most commercially available supplements fed to cattle are palatable and potentially could be used to lure animals to underutilized rangeland. Dehydrated molasses supplements are available in containers (blocks weighing up to 250 lbs. or 113 kg) that can be transported to rugged rangeland and then self fed. Most

containers last up to 2 weeks before they are emptied and should be replaced to maintain intake. Bailey and Welling (1999) showed that cattle spent more time and grazed more forage in pasture areas where dehydrated molasses supplement was provided than in similar control areas where no supplement was provided. Although it was more effective in moderate terrain (10-20% slopes), strategic supplement placement noticeably changed livestock grazing patterns in steeper terrain (15-30% slopes) at greater distances from water.

Distance from Supplement

To evaluate if using dehydrated molasses supplement to modify livestock grazing distribution is cost effective, the distance that grazing distribution is effected by supplement placement must be estimated. Studies conducted in northern Montana (Bailey et al., in press) used three approaches to examine grazing use at varying distances from supplement placement. The first approach was to measure forage utilization at incremental distances from supplement. In a study conducted in 1997 (Bailey and Welling, 1999), forage utilization was measured at distances from 22 to 220 yards (20 to 200 m) from supplement. Forage use measurements clearly showed that forage use was similar at all distances measured. In a 1998 study (Bailey et al., in press), forage utilization was measures at distances from 55 to 660 yards (50 to 600 m) from supplement. Again, forage use was similar at all distances measured. In 1999, forage utilization was measured at distances from 220 yards to over 1.5 miles (200 to 3000 m) from supplement, and grazing use decreased linearly as distance from supplement increased. Using the 1999 forage utilization data set, the distance from supplement that grazing use was no longer effective was estimated to be 660 yards (600 m). Thus, grazing use is enhanced by supplement placement relatively uniformly for distances up to 660 yards (600 m), but at further distances the effect of supplement placement diminishes rapidly.

The second approach to examine grazing use at incremental distances from supplement was horseback observations. In 1998, riders recorded the positions of cattle two times per week. Cattle were not distributed uniformly across the two study pastures. In both pastures, 18% of cows were within 200 m of supplement, and these areas made up less than 10% of the pasture acreage. In one pasture, 58% of the cows were observed within 660 yards (600 m) of supplement, but the area within 660 yards made up only 38% of the total pasture acreage. In the other pasture, 38% of the cows were observed within 660 yards (600 m) of supplement, which was equivalent to 26% of the pasture acreage. A disproportionate number of cattle were observed near supplement even though supplement was placed in areas that included some of the steepest slopes and furthest areas from water in the pastures.

The third approach to evaluate grazing use at various distances from supplement was to track cows with GPS collars. Locations of supplement were recorded using a backpack GPS unit with an accuracy of within 1.1 yards (1 m). Collared cows spent about 16% their time within 200 yards of supplement. Collared cows spent between 33% to 40% of their time within 600 m of supplement (areas far from water and with steep slopes). Figure 2 illustrates how cows often spent a great deal of time near supplement.

Visits to Supplement

Cattle visited supplement at all times of the day. A visit was defined as a recorded location of collared cows within 11 yards (10 m) of supplement. During October when temperatures were warmer cattle visited supplement more often during daylight hours. Later in November and December, cattle visited supplement more often at night. During the last two-week period in January, cattle visited supplement more often during the day. The more frequent use of supplement at night during colder weather was unexpected and could have been documented only with the use of GPS tracking collars.

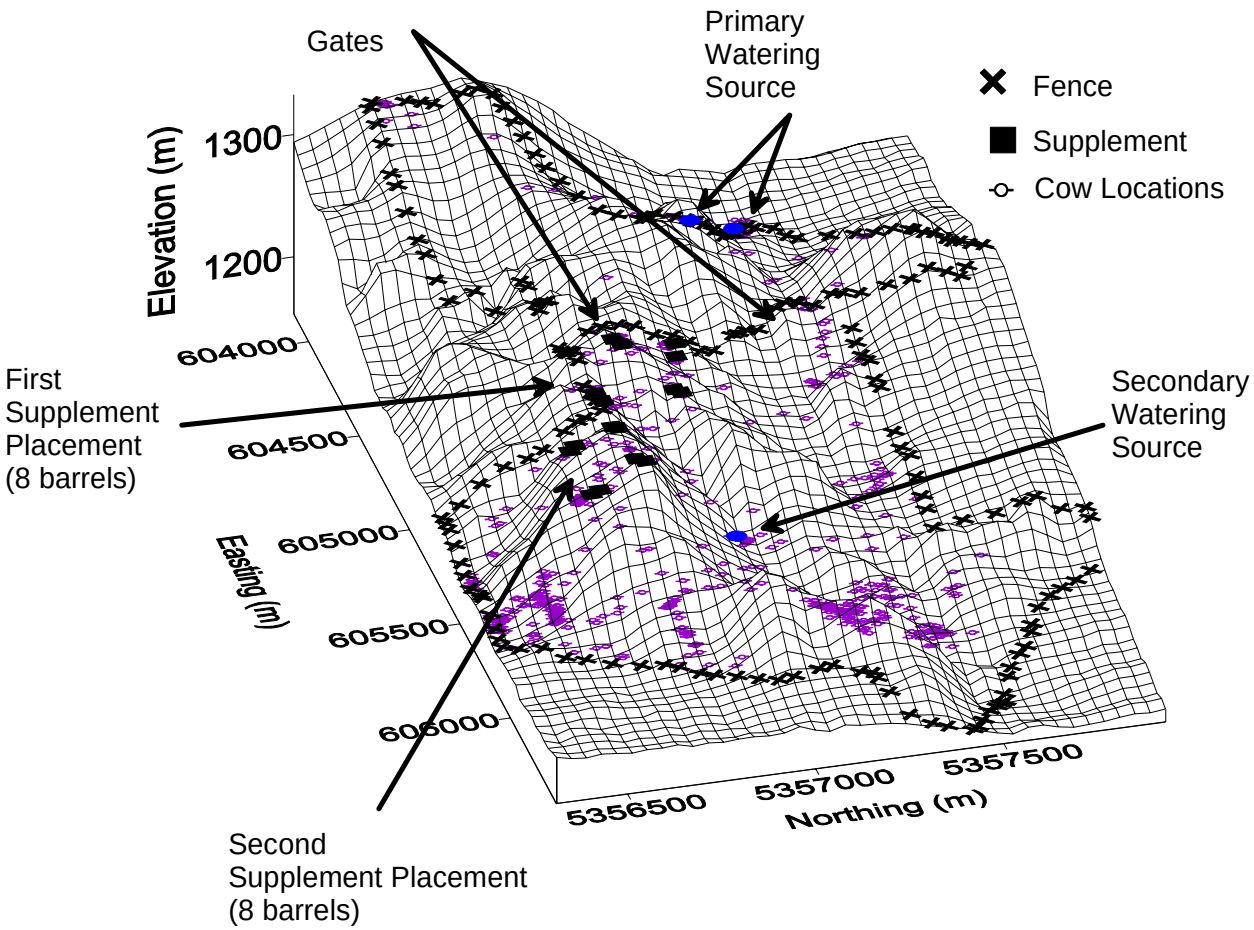

Figure 2. Locations of cow 4115 during October 1998. Eight supplement barrels were placed in two general locations. This cow was tracked during the last three days of the first placement and the first three days of the second placement. The location of this cow was recorded every 10 minutes. The pasture was divided into two sections but gates were opened to allow access to both sections. Water was available in two general locations, but there was only sufficient water for about 50 of the 159 cows in the pasture at the secondary watering location.

Effect of Wind Chill

Over the duration of the study, horseback observers usually sighted an average of one cow at every barrel (250 lb. or 113 kg block) of supplement. When temperatures were below freezing and the wind chill was much lower than ambient temperature as a result of wind, cows often avoided the exposed areas where supplement was located. Since the objective of the study was to evaluate how well supplement could be used to lure cattle to underutilized rangeland, supplement was placed in higher elevations where cattle usually did not graze. Correspondingly, these areas were exposed and not protected from the wind. When ambient temperatures were warm, wind had little effect on where cattle grazed. However if ambient temperature was below freezing (32º F or 0º C), cows rarely visited supplement if the average daily wind speed was over 10 miles per hour (16 km / hour).

During late December and early January, cows did not visit supplement for two weeks. This two-week period had the coldest ambient temperatures and wind chills of the study. We were not able to retrieve the supplement at the end of that period as the study protocol prescribed because of deep snowdrifts.

During the next and final period, half of the supplement was placed in protected terrain (coulees). Temperatures and wind speeds were milder than during the previous period. Cattle consumed nearly all the supplement placed at the beginning of the final period, and they also found and consumed supplement that was placed during the previous period, which had been previously avoided and was nearly covered by snowdrifts. Figure 3 shows a collared cow that visited supplement placed at beginning of the final period and also visited previously unused supplement.

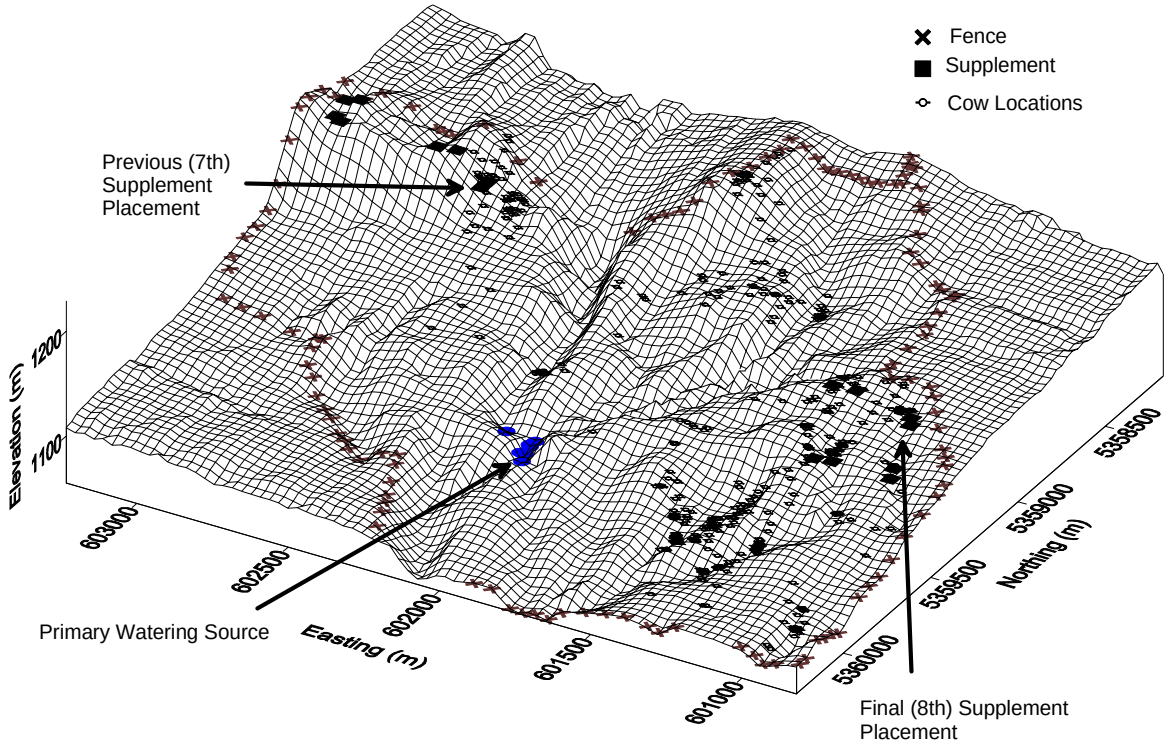

Figure 3. Locations of cow 2213 recorded every 15 minutes during the last (8th) two-week period in mid-January 1999. Supplement was available in two locations. Each location had eight barrels. The previous (7th) placement could not be picked up as protocol prescribed due to impassable snowdrifts. Cattle had not found or consumed the supplement during the previous two-week period. The supplement placed for the last period was placed in protected and unprotected terrain. Cows consumed nearly all the supplement placed for the eighth period, and later found the supplement placed for the seventh period that was partially buried in snow drifts.

Frequency and Duration of Supplement Visits

Except in cold windy weather, most cows visited supplement 0.5 (every other day) to two times per day. Of the 81 cows that were collared during the study, only six cows visited barrels four or more times per day. When cows visited supplement, they usually spent between 20 to 60 minutes at the barrel. Visits over 60 minutes were rare.

FUTURE RESEARCH

The potential for using selection to improve livestock distribution is currently being evaluated at the Northern Agricultural Research Center and at a cooperating ranch (Ross Ranch) in Montana. Cows were

separated into two groups, “hill climbers and bottom dwellers,” based on their use of rugged foothill rangeland. The hill climber and bottom groups were grazed in similar, but separate, pastures. Grazing patterns are being documented using GPS tracking collars and horseback observers. Forage utilization measurements are also being used to compare the distribution patterns of the hill climber and bottom dweller groups. The study will continue through 2001.

The effect of dehydrated molasses supplement has been evaluated during late summer, fall and winter. However, many resource concerns with livestock grazing occur during the summer. Studies are planned to determine if supplement can improve uniformity of grazing during the summer. Herding has been historically used to improve uniformity of grazing. However, many livestock producers are uncertain with the effectiveness of herding to prevent distribution problems. Studies are planned to evaluate the effectiveness of herding and to determine if combining herding with strategic supplementation can improve uniformity of grazing and prevent distribution problems such as overgrazing of riparian areas.

Tracking data collected from previous and planned studies will be used to develop and test a predictive grazing distribution model. This predictive simulation model will based on existing models such as conceptual model described by Bailey et al. (1996). The goal of this modeling research is to allow land managers to predict changes in livestock grazing distribution from planned management actions (e.g., supplement placement, herding or water developments) in their pastures and under their conditions.

CONCLUSIONS AND IMPLICATIONS

Ongoing research suggests that selection for improved grazing distribution may be effective, but more research and analysis is needed before any conclusions can be made. Cattle that were developed in mountainous terrain (Tarentaise from the French Alps) used higher terrain and in one of two years of the study steeper slopes than cattle developed in more gentle terrain (Herefords from England). Cows tended use terrain similarly for two consecutive years in the same pasture demonstrating that grazing patterns may be a repeatable trait. No adverse relationships were observed between grazing patterns and performance of a cow or her calf. Thus, culling cows based on terrain use should not reduce performance of the herd. Using GPS collars to track cattle greatly enhanced our ability to detect differences in grazing patterns of individual animals.

Strategic placement of dehydrated molasses supplement can lure cattle to underutilized rangeland. Supplement enhances grazing use of rugged rangeland relatively uniformly for distances up to 660 yards (600 m). At further distances (> 660 yards), effects of supplement placement diminish rapidly. Cows visited supplement at all times of the day, and in some cases cows spent more time at supplement during the dark than during daylight hours. When temperatures were below freezing (32º F or 0º C) and the wind chill was much lower than ambient temperature as the result of wind, cows often avoided supplement placed in exposed terrain. To ensure intake during cold and windy weather, supplement should be placed in protected areas that receive less wind. Planned research will further evaluate the use of dehydrated molasses supplement to improve uniformity of grazing and to resolve livestock distribution concerns.

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