THE INFLUENCE OF SEASON ON DISTRIBUTION PATTERNS RELATIVE TO WATER AND RESOURCE USE BY CATTLE GRAZING MIXED FORESTED RANGELANDS

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Summary

Sustainable watersheds and resource use may be key factors determining the future of public land grazing in the western U.S. At the Starkey Experimental Forest and Range (SEFR), deer, elk, and cattle interactions are being studied in a free ranging environment within a 78-km^2 study area enclosed by a 2.4-m-high fence. Cattle are moved through pastures on a deferred-rotation schedule. Pastures grazed early in one year will be grazed late the following year. We evaluated distribution relative to water and vegetation resource use by cattle in two pastures that, depending on rotation, were grazed either early or late. We linked cattle locations (n = 52,536) determined with an automated telemetry system from 1991 to 1996 to a geographic information system (GIS) of the SEFR. Between and within seasons, cattle displayed strong patterns of spatial distributions and selection of resources on an hourly basis. Feeding sites for cattle were significantly different ($P < 0.05$) between seasons relative to distance to water, structure of the vegetation, and canopy cover. In late summer, cattle were closer to water and grazed in stands with higher percent canopy cover. Cattle grazing early summer pastures, as resources were consumed and vegetation dried, shifted distributions to more concave slopes, moved closer to water, sites with higher forage production, and more northerly aspects ($P < 0.05$). In late summer, patterns were reversed. In the first half of late season grazing, cattle selected areas closer to water, higher forage production areas, and northerly aspects, but as resources were removed, cattle used areas far from water, more concave sites, and areas with deeper soils ($P < 0.05$). In summary, scheduling timing of grazing has substantial effects on forage utilization and distributions relative to use for riparian areas.

Introduction

Grazing strategies and systems that promote uniform distribution and forage use are essential to sustainable beef production on western rangelands. Current issues relative to threatened and endangered species (specifically salmon, steelhead, and bull trout) and the federal Clean Water Act have focused considerable attention on management of riparian areas. Management of grazing to promote riparian biological diversity, streambank stability, and overall sustainability holds potential keys to continued use of public lands by the livestock industry.

Numerous factors influence the distribution of cattle relative to riparian areas. Topography characteristics such as slope, aspect, canopy, and vegetation all influence and drive animal distribution. Animal factors such as age, lactation, stage of lactation and possibly breed type also may modify the distribution of beef cattle in range environments. Likewise, ambient air temperatures and subsequent water requirements that effectively help regulate body temperature and meet metabolic demands also influence the relative needs of beef cattle for riparian areas and associated habitat.

Optimal management of beef cattle in free-ranging environments, therefore, requires understanding the dynamics of the animals' physiological requirements (i.e., thermoregulation) as modified by diverse vegetation and topography. The objectives of this study were to evaluate and compare distributions and resources selected by cattle relative to daily activity patterns, early versus late summer use, and duration of grazing in two dissimilar allotment pastures.

Materials and Methods

Study area. We conducted this project on the Starkey Experimental Forest and Range (SEFR), which is located in the Wallowa-Whitman National Forest, 35 km southwest of La Grande, in northeastern Oregon. The SEFR consists of a 101-km^2 area enclosed by a 2.4-m ungulate-proof fence. The site is typical of mixed forested rangelands in the intermountain west with vegetation consisting of bunchgrasses, ponderosa pine (*Pinus ponderosa*), Douglas fir (*Pseudotsuga menzienzii*), grand fir (*Abies grandis*), and lodgepole pine (*P. contorta*). Elevations range between 1,100 and 1,400 m with annual precipitation averaging 64 cm, 60 percent coming during the winter period. The main study area (77.6 km^2, Figure 1) used for this project consisted of four pastures used in a deferred rotation grazing system. Specifically, during odd-numbered years, cattle (500 head allotment) graze the pastures in the following order. Smith-Bally, Halfmoon, Bear, and Campbell. In contrast, during even-numbered years, cattle are grazed in reverse order beginning with the Campbell pasture (mid-June to mid-July) and ending with the Smith-Bally pasture (early-September to mid-October). For this project, we limited our analysis to the Smith-Bally and Campbell pastures because they were grazed either early or late, depending on year.

Monitoring animal locations. Locations of cattle were monitored in the main study area from 1991 to 1996 with a LORAN-C automated telemetry system (ATS; Rowland et al., 1997). Attempts were made to locate an animal every 20 seconds with animals assigned to a 30- x 30-m pixel within the main study area. Mean position error of the ATS was $\pm$ 53 m (SE = 5.9 m; Findholt et al., 1996). Each location also was corrected for spatial biases (Johnson et al., 1998).

Habitat variables. Animal locations then were linked to a geographical information system (GIS) for the SEFR. Specific variables related to habitat characteristics were derived from the literature and tested for collinearity (Johnson et al., 2000). Selected habitat characteristics used in our analysis included percent slope, convexity, sine of aspect, cosine of aspect, distance to class 1 and 3 water sources (perennial streams), soil depth, distance to forage, and canopy cover of trees (> 4.9 cm dbh).

Statistical analysis. To estimate resource selection, we used locations obtained within 4 hr after sunrise and 4 hr before sunset, and we restricted our analysis to animals with greater than 29 locations within the time intervals we analyzed. We used logistic regression (SAS, 1997) in a stepwise backwards-approach to identify variables to calculate resource selection functions specific to season of grazing and time within a given pasture (first half of grazing versus second half). Additionally, a jackknife process was used to test the significance of the coefficients by repeating the analysis and sequentially dropping a different animal from the data set for each iteration. Variables with the highest P value were dropped sequentially from the model, until

only significant variables ($P < 0.05$) remained. To examine for differences between the first half of the early summer grazing season and the first half of the late summer grazing season, we tested for interaction with each variable that was significant in either of the initial models.

Results

Smith-Bally Pasture. Contrasting patterns in resource selection were evident between and within seasons, and resource selection was influenced strongly by season of use. During the first half of the early season, cattle selected gentle slopes, southerly aspects, areas close to water, deep soils, and areas with low canopy ($P < 0.05$; Table 1). In contrast, cattle selected in the first half of the late season northerly aspects, concave sites, more productive sites as indicated by greater coefficients relative to soil depth, and areas close to forage ($P < 0.05$; Table 1). During the late season of use, cattle did not select resources based on distance from water ($P > 0.10$), but late season cattle were closer to water than early season distributions of cattle throughout the day (Figure 2).

The second halves of both early and late season grazing periods displayed contrasting relationships, as well, with forage utilization presumably resulting in shifts in resources selection. Specifically, during the second half of early season grazing, cattle shifted away from water and selected more steep slopes and less concave slopes (Table 1; $P < 0.05$). In contrast, as forage became limited during the late season, cattle selected steeper concave slopes, northerly aspects, and areas further from water (Table 1; $P < 0.05$). Comparing resources selected during the first halves of early and late season grazing, sine of aspect, cosine of aspect, convexity, distance from water, distance from forage, and tree canopy cover all differed ($P < 0.10$).

Campbell Pasture. Like the Smith-Bally pasture, cattle distribution was influenced strongly by season of use. Specifically, when evaluating the interaction of early versus late season grazing (during the first half of the grazing period), distance from water, distance from forage, and tree canopy cover all were different ($P < 0.10$) in terms of mediating cattle distribution. Specifically, cattle tended to select areas closer to water and with higher percent canopy cover (Table 2). As forage was removed from the pastures during both early and late season grazing, resource selection shifted. Cattle grazing early season moved toward water, more northerly aspects, and areas of higher forage production ($P < 0.05$) as forage availability became limited in the second half of allotment pasture grazing. In contrast, cattle grazing late season pastures moved away from water toward steeper concave slopes and greater soil depth ($P < 0.05$).

Discussion and Management Implications

Beef cattle distributions in forested rangelands are influenced strongly by season of use, forage availability, habitat characteristics, and the environment. Results of this study suggest that early season distribution is much more uniform, with cattle selecting habitats with greater slope and greater distances from water. In contrast, late season grazing distribution is more concentrated in areas close to water and with higher tree canopies and more northerly aspects. Additionally, as length of grazing increased and forage availability became limited, cattle shifted resource selection toward areas of greatest forage availability.

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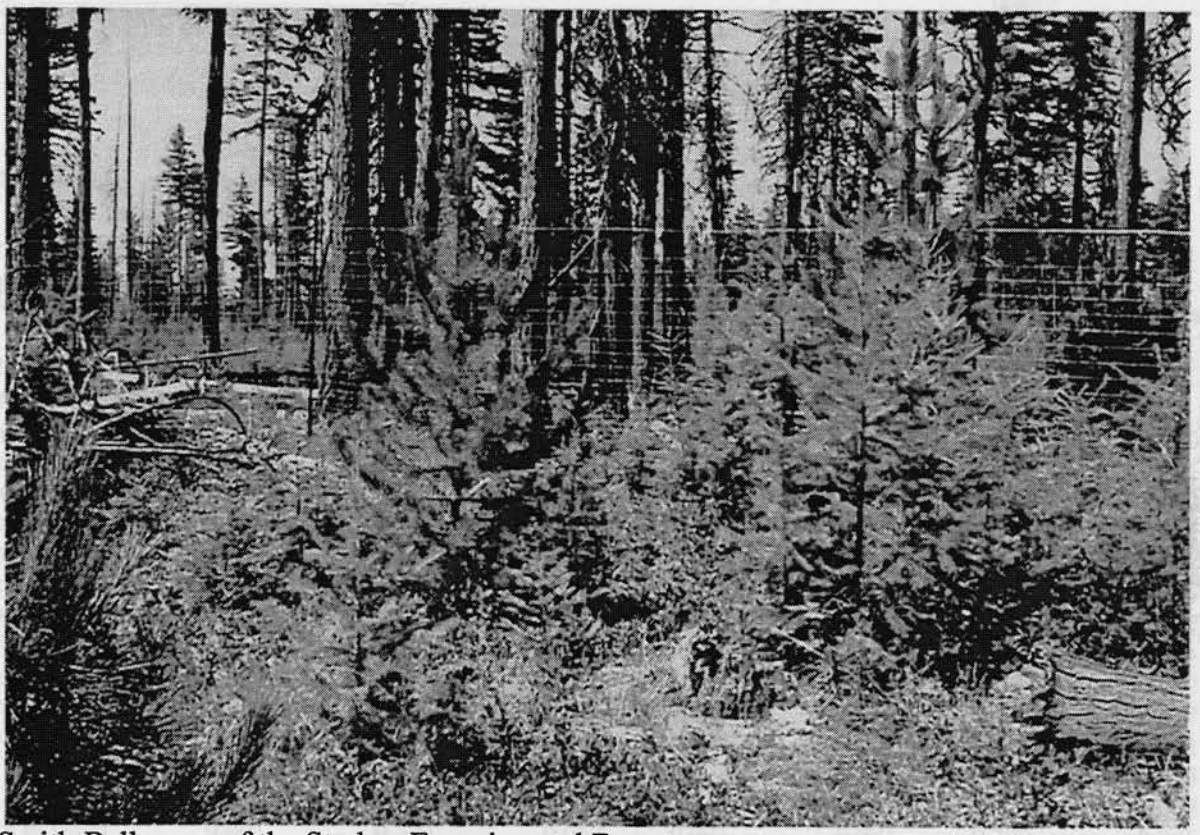

Smith-Bally area of the Starkey Experimental Forest.

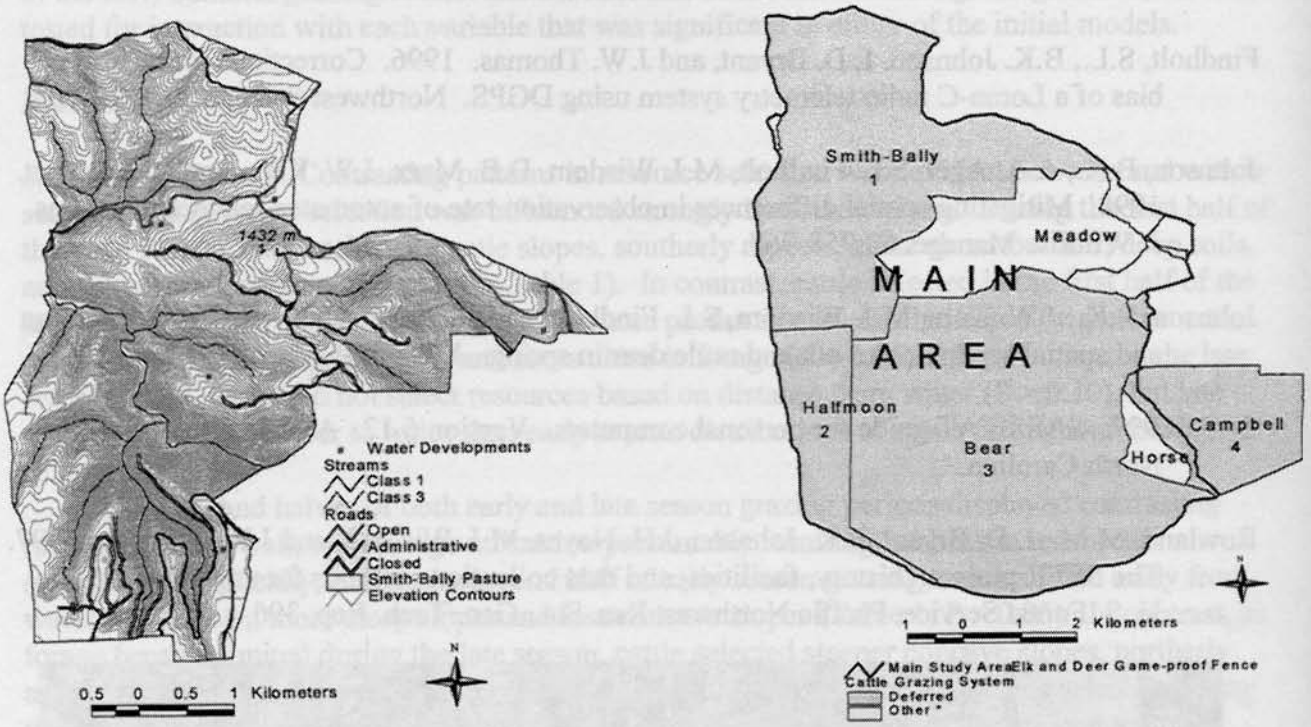

Figure 1. Beef cattle distributions were determined using an automated telemetry system and applying to GIS images for the Starkey Experimental Forest and Range. The cattle were managed in a deferred rotation system corresponding to the four shaded pastures, which comprised the main study area (right image). Cattle locations then were evaluated in terms of distance from water and habitat characteristics for the Smith-Bally and Campbell Pastures. The physical layout of the Smith-Bally Pasture is shown on the left.

Table 1. Variables of resource selection functions of cattle grazing mixed forested rangelands in early summer (1991, 1993 and 1995,) and late summer (1994, and 1996) within Smith-Bally pasture, using locations obtained with a LORAN-C automated telemetry system, Starkey Experimental Forest and Range, northeastern Oregon.

Variable	Cattle resource selection during early season of use				Cattle resource selection during late season of use			
	β	Standardized β	SE[a]	P	β	Standardized β	SE	P
First half of pastures use:								
Intercept	-1.657	-1.980	0.071	0.001	1.156	-2.414	0.079	0.001
Percent slope	-0.027	-0.348	0.059	0.001				
Convexity					-0.007	-0.045	0.024	0.054
Cosine of aspect	0.168	0.118	0.035	0.001	0.304	0.212	0.043	0.001
Distance to water	0.002	0.286	0.033	0.001				
Soil depth	0.007	0.089	0.022	0.001	0.009	0.119	0.040	0.003
Distance to forage	-0.005	-0.176	0.042	0.001	-0.002	-0.061	0.030	0.046
Second half of pastures use:								
Intercept	2.600	-3.495	0.059	0.001	6.435	-2.932	0.061	0.001
Percent slope	-0.023	-0.301	0.301	0.083	-0.010	-0.139	0.062	0.024
Convexity	-0.011	-0.067	0.029	0.020	-0.091	-0.115	0.029	0.001
Sine of aspect					-0.180	-0.129	0.035	0.001
Cosine of aspect	0.125	0.087	0.044	0.050				
Distance to water					0.001	0.119	0.048	0.013
Soil depth					0.012	0.152	0.041	0.001
Distance to forage	-0.003	-0.111	0.037	0.003	-0.004	-0.150	0.036	0.001

[a] Standard error (SE) is of standardized β

Table 2. Variables of resource selection functions of cattle grazing mixed forested rangelands in early summer (1994 and 1996,) and late summer (1991, 1993, and 1995) within Campbell pasture, using locations obtained with a LORAN-C automated telemetry system, Starkey Experimental Forest and Range, northeastern Oregon.

Variable	Cattle resource selection during early season of use				Cattle resource selection during late season of use			
	β	Standardized β	SE[a]	P	β	Standardized β	SE	P
First half of pastures use:								
Intercept	19.906	-0.387	0.054	0.001	47.970	-0.562	0.070	0.001
Percent slope	0.026	0.117	0.026	0.001	0.019	0.094	0.031	0.003
Convexity	-0.042	-0.099	0.023	0.001	-0.097	-0.266	0.030	0.001
Distance to water	0.001	0.165	0.056	0.003	-0.001	-0.371	0.074	0.001
Soil depth	0.012	0.101	0.031	0.001				
Distance to forage	0.004	0.067	0.021	0.001	-0.007	-0.121	0.039	0.002
Grazing canopy					0.010	0.165	0.037	0.001
Second half of pastures use:								
Intercept	16.413	-0.792	0.057	0.001	73.541	-0.591	0.072	0.001
Percent slope	0.018	0.079	0.027	0.003	0.041	0.184	0.027	0.001
Convexity	-0.036	-0.081	0.025	0.001	-0.150	-0.368	0.041	0.001
Sine of aspect					0.206	0.104	0.055	0.059
Cosine of aspect					-0.243	-0.158	0.058	0.007
Distance to water	0.001	0.221	0.057	0.001	0.001	0.320	0.055	0.001
Soil depth	0.011	0.097	0.032	0.002				

[a] Standard error (SE) is of standardized

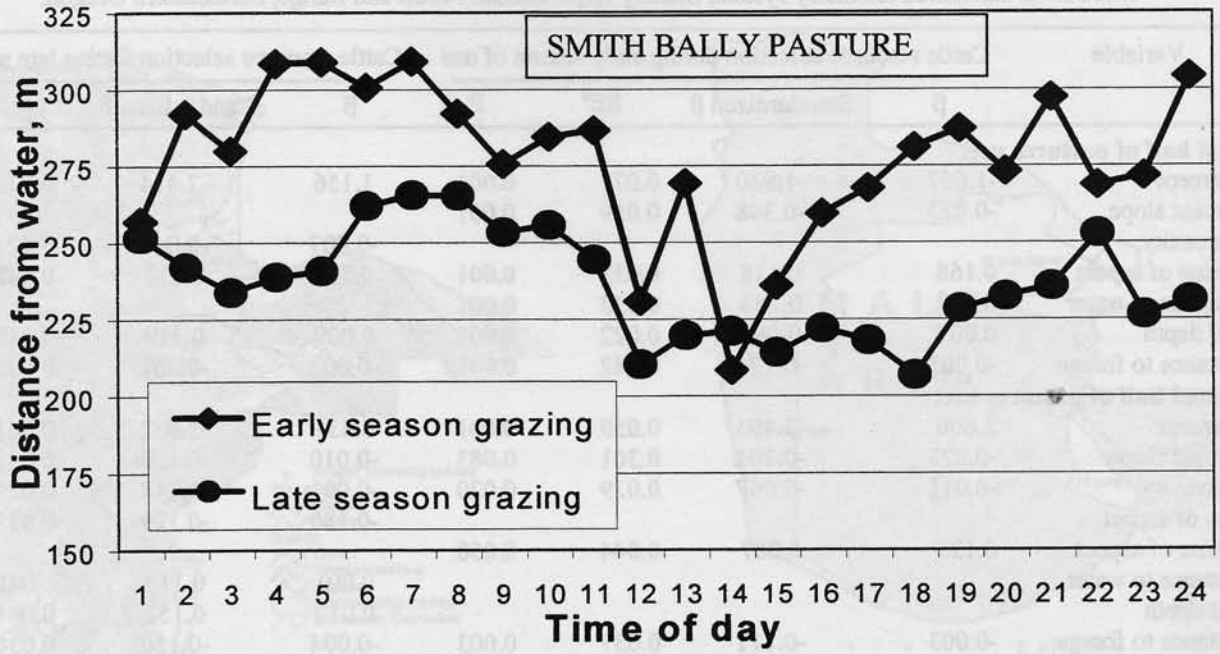

Figure 2. Mean distance of cattle to perennial streams during early and late summer grazing on an hourly basis in Smith-Bally Pasture, Starkey Experimental Forest and Range, northeast Oregon, 1991-1996. Diurnal patterns of beef cattle distribution relative to class 1 and 3 streams were influenced by season of use. Early season use reflects observations obtained in 1991, 1993, and 1995, whereas late season distribution was derived from 1994 and 1996 grazing seasons.