Cattle Distribution on Steep Slopes

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Highlight

Steepness of slope of a grazing area considerably influences distribution of cattle. On a 10% slope where access is only from the bottom, 75% of cattle use is likely to be within 810 yards of the foot of the slope. On a 60% slope, 75% of use is likely to be within only 35 yards of the foot of the slope. Distribution is also influenced by distance from water.

Range managers in mountainous country are constantly faced with the problem of determining the proportion of the range that can be used readily by cattle. They know in a general way that steepness of slope, roughness of terrain, distance from water, and type of vegetation influence animal distribution. However, specific quantitative information about the relative importance of these factors to the total problem of animal distribution and, consequently, patterns of grazing use, is needed to guide management effectively.

This paper reports a study designed to provide such quantitative information about the effects of slope steepness on distribution of animals. Its intent is to guide ranchers in managing grazing on steep slopes. Earlier studies reported the effect of availability of water (Holscher and Woolfolk, 1953; Talbot, 1926; Valentine, 1947), the desirability of improving distribution of water (Costello and Driscoll, 1957; Goebel, 1956), and how steep slopes and rough topography hinder cattle movement (Phinney, 1950; Stoddart, 1960). Inaccessible and partly accessible areas should be discounted in computing stocking rates for moderate use of readily accessible range.

The Study

Description of study area.— This study of the influence of slope steepness was conducted on mountainous livestock range in southwestern Montana during the summer of 1961. Vegetation on the study areas was primarily bunchgrass communities dominated by bluebunch wheatgrass (*Agropyron spicatum*), Idaho fescue (*Festuca idahoensis*), Sandberg bluegrass (*Poa secunda*), needlegrasses (*Stipa* spp.), and occasionally big sagebrush (*Artemisia tridentata*).

Thirty-eight study areas ranging in slope steepness from zero to 78% were selected on the basis of these criteria:

1. Reasonable uniformity of steepness.
2. Accessibility to cattle only from the bottom of the slope.
3. Length of slope extending above the area of appreciable use.
4. Grassland cattle range in fair to good condition.

Field procedures.—Distribution of cattle use was measured by counts of cow chips on a series of belt transects located at 100-yard intervals up each slope. Each transect was 14 feet wide and extended 150 yards along the slope contour. The number of transects per slope depended upon the distance animal use extended up the slope, and varied from as few as four transects on very steep slopes to as many as seventeen on gentle slopes. The first transect was always located at the foot of the slope. Wherever possible, two or three transects were located beyond the zone of obvious use; but on some gentle slopes, traces of use continued to the top.

Number of cow chips per transect was used as an index to animal distribution and relative use (relative occupancy time). Such an index had been used in earlier range studies (Julander, 1955; Johnstone-Wallace and Kennedy, 1944) even though Julander had noted a concentration of chips close to water, salt, and bed grounds. Because the chips remained recognizable for at least 3 years, with age indicated by weathering, the single count provided a measure of relative use over a period of several years. Relative use on any one transect was obtained by expressing the number of well-defined chips on that transect as a percent of the total number of chips for all transects on the slope.

Some measure of grazing pressure at the bottom of each slope was considered desirable because it might be expected to influence animal distribution upslope. The total number of chips on the first three belt transects from the foot of the slope was the basis for this index of grazing pressure.

Site factors recorded for each transect included: percent slope, percent surface rock over 3-inch diameter, distance from water and from salt, and percentage of palatable grasses in the sward. Percent slope was measured by an Abney level; the other factors were estimated. In analysis, some of these records proved to have little value for various reasons. For example, the amount of surface rock encountered seemed not to impede animal movement. Again, the foot of the slope happened always to be nearest to drinking water; and since 36 of the 38 slopes had water within 300 yards of the bottom, accessibility of water was not restrictive. Also, distance from water and distance upslope were closely associated. Distance from salt was not a usable measure because salt grounds often could not be located. The proportion of palatable grasses on the slopes studied varied little except near the bottom. Therefore, the only meaningful variables in this study were percent slope and distance upslope.

Analysis

The data were analyzed by multiple regression. Percent slope, distance upslope, and the index of relative grazing pressure were the independent variables. Accumulated relative use was the dependent variable. Each of the 354 transects represented an individual observation.

Preliminary graphical analysis of the effect of distance upslope on relative use indicated a curvilinear relationship of a negative exponential type. In other words, for any particular slope steepness, cattle use was greatest at the bottom, rapidly diminished within a comparatively short distance from the bottom, and diminished more gradually thereafter with distance upslope. Therefore, distance was treated as an exponential function in the multiple regression analysis. Percent slope and grazing pressure were treated as linear functions.

With accumulated relative use as the dependent variable, multiple regression was first computed using three independent variables: distance upslope, percent slope, and relative grazing pressure. A highly significant multiple correlation coefficient (R) of 0.90 was obtained ($F = 513$; $df = 3$ and 350). The contributions of percent slope and distance upslope to the prediction of relative use were highly significant ($t = 29$ and 32, respectively, with 352 df) and important. Combined, these two variables accounted for 81% of the variation in relative grazing use ($R^2 = 0.81$). Separately, they were less effective. The simple correlation coefficient for steepness of slope and relative use is -0.51, and that for distance upslope and relative use is -0.47. Thus, percent slope (X_1) and distance upslope (X_2) independently account for 26 and 22 percent, respectively, of the variation in relative grazing use.

Including the grazing pressure index as a third independent variable improved the prediction equation very little. Although its effect was significant at the 95% probability level, its influence was relatively minor; the ratio of the reduction in sum of squares by its influence to total sum of squares was only 0.003. Its inclusion increased the multiple correlation coefficient less than 1%.

This small apparent influence of the grazing pressure index is surprising since increased pressure logically could be expected to force grazing higher upslope and farther away from water. Evidently such pressure was not reflected by the index used in this study. The index (based on number of cow chips at the base of the slope) reflected occupancy time throughout a seasonlong grazing period under relatively "moderate" rates of stocking. It is an unfamiliar expression, and somewhat troublesome to obtain. Since it contributed little to the prediction of relative grazing use, it was omitted from the final analysis.

The following equation predicts relative grazing use from slope steepness and distance upslope under the conditions of this study:

$$\hat{Y} = 107.06 + 1.00X_1 - 95.37e^{-0.001X_2}$$

where $\hat{Y}$ = predicted accumulated relative use to the specified upslope distance, considering total use on area as 100%

X_1 = slope steepness in percent

X_2 = distance upslope in yards

e^{-X_2} = exponential function of X_2 (obtainable from standard mathematical tables).

The coefficient of multiple correlation, 0.90, is highly significant ($F = 754$; $df = 2$ and 351). The standard error of predicted relative use is 11% at the mean.

The above formula provides the curves (Fig. 1) that graphically illustrate this relation. These results are considered applicable to northern mountain grasslands under a moderate stocking rate of 2 to 4 acres per cow month, seasonlong. The relation between use, or relative occupancy time, and distance upslope can be determined readily from the slope curves. For example, 75% of the cattle use on a 10% slope, where access is only from the bottom, will probably occur within 810 yards of the foot of the slope; whereas, 75% of the cattle use on a 60% slope will probably occur within only 35 yards of the bottom. Figure 1 strikingly illustrates the progressive decrease in cattle movement upslope as slope steepness increases.

The relative time cattle spend at various distances upslope is shown in Table 1 as a percent of the time that they spend within 100 yards from the bottom of the slope. For example, areas 200 yards up 30 or 60% slopes are occupied only 20 and 11%, respectively, as much as areas at the bottom. The data for 0% slope largely reflect the effect of distance from water. Data for the 10 to 70% slopes represent the combined effect of slope steepness and distance from water. The effect of slope alone at a given distance from its base can be obtained by subtracting the value given for the slope from the corresponding value shown for 0% slope. These values are shown in parentheses in Table 1.

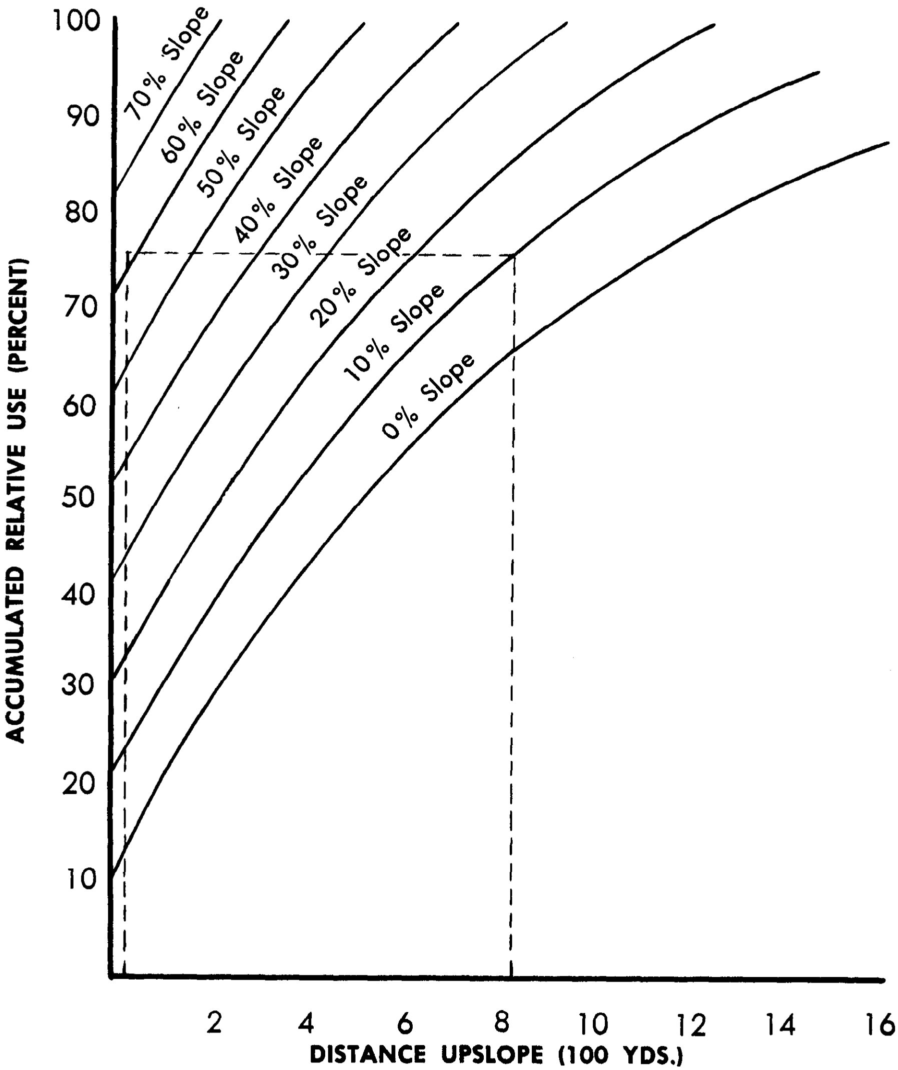

FIGURE. 1. Influence of slope steepness and distance upslope on relative cow use.

Table 1. Relative time (in percent) cattle spend at different distances up slopes of various steepness. Effect of slope alone is shown in parentheses.

Distance upslope (yards)	Percent slope							
	0	10	20	30	40	50	60	70
0	100	100	100	100	100	100	100	100
100	78	42	29	22	18	15	13	11
		(36)	(49)	(56)	(60)	(63)	(65)	(69)
200	70	38	26	20	16	13	11	10
		(32)	(44)	(50)	(54)	(57)	(59)	(60)
300	63	34	23	18	14	12	10	0
		(29)	(43)	(45)	(49)	(51)	(53)	
400	57	31	21	16	13	11	0	
		(26)	(36)	(41)	(44)	(46)		
600	47	25	17	13	11	0		
		(22)	(30)	(34)	(36)			
800	38	21	14	11	0			
		(17)	(24)	(27)				
1000	32	17	12	0				
		(15)	(20)					
1400	21	12	0					
		(9)						

Summary

Slope steepness significantly influenced distribution of cattle on mountainous bunchgrass range in southwestern Montana. Animal distribution was indicated by relative use, or occupancy time, of various portions of the slope as determined by the number of cow chips.

A negative exponential relation exists between accumulated relative use and distance upslope from the bottom. A multiple curvilinear regression formula can predict accumulated relative use from percent slope and distance upslope. The correlation coefficient for this regression is 0.90; the standard error of predicted values is 11%.

The effect of slope steepness on cattle movement upslope is illustrated graphically.

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