Factors Affecting Utilization of Mountain Slopes By Cattle[1]

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Highlight

Many factors affect the utilization of mountain terrain by cattle and these factors are interrelated and exert their influence in a complicated manner. Actual use obtained under good management is the most accurate method of determining the utilization obtainable on a particular mountain slope.

Cattle normally graze heavily on valley bottoms and more level land near water before moving onto rougher terrain. They tend to use some slopes extensively and others only slightly or not at all. During the period of the interagency range surveys (1937 to 1940), estimated capacity of mountain ranges was adjusted on the basis of percent slope in order to allow for the effect of topography (Interagency Range Survey Committee, 1937). Other utilization adjustments involved distance from water, rockiness, and prevalency of down timber. By influencing the use that can be made of the forage, these and other factors affect the actual carrying capacity.

The number of livestock that can be grazed on a mountain range depends to a large degree upon the utilization that can be attained on the rougher portions of the range when the more undulating terrain is properly used. Range technicians therefore, are seeking a method of predicting the degree of use that might be secured on mountain range slopes.

[1] *A cooperative study between the Utah State University and the Intermountain Forest and Range Experiment Station.*

Materials and Methods

During the summer grazing seasons (June 10 to September 10) of 1962, 1963, and 1964, a study was conducted on mountain range in northern Utah to determine the effects of location of water, location of salt, topography, and vegetation cover on the utilization of mountain slopes. A view of a portion of the study area is shown in Fig. 1.

The range had aspen, sagebrush-grass, and mountain brush types intermixed. It was between 6,000 and 7,000 ft elevation on the Cache National Forest with slopes ranging from 5 to 55% in all types. These ranges are typical of much of the Intermountain area. The study area consisted of three fenced pastures of about 2 sections each where about 800 cows with their calves were grazed. During the summer of 1962 the cattle were grazed in 3 separate herds in the 3 pastures. During the summers of 1963 and 1964 they were grazed as one large herd and rotated among the 3 pastures. The cattle were drifted[2] away from water

[2] *The term "drifted" as used herein means that animals are directed or driven short distances in a slow, rather normal grazing manner to an area frequented by only a relatively few animals otherwise.*

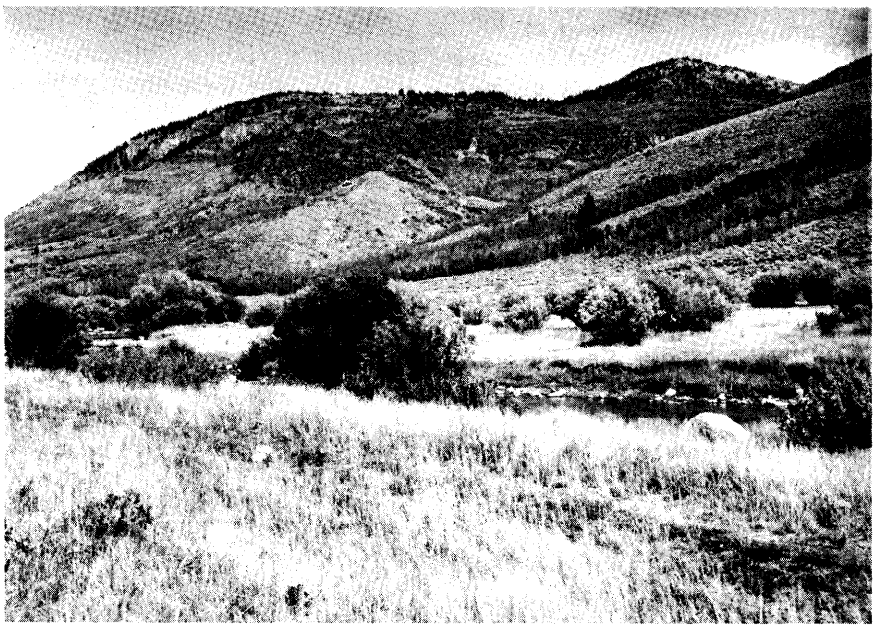

FIG. 1. Mountain range used by cattle during the summer. Available water in the streams concentrates cattle in the adjacent bottom lands. Topography, brush, distance from water, and salting all influence use of the slopes.

holes and bottom lands twice a week to prevent undue concentration.

There were 74 study sites of approximately an acre in size along two transect lines in each pasture, making a total of 222 study sites or plot locations. Plots were located along the transect lines at random. Additional plots were located on the bottom lands along the main streams in each pasture. These plots along the main river bottoms were used as standards in trying to obtain the same degree of use in each pasture. The 222 study plots were permanently located and were representative of all topographic features present in the 3 pastures including vegetation types, aspects, slopes, and bottom lands in secondary drainages. None of the plots that randomly fell on a ridge top was included in the study because all plots had to be somewhere below a salt location. This was necessary to evaluate the effect of salt above the study sites.

During 1962 and 1964 the animals were removed from each pasture when utilization of the grasses in the bottom lands along the live streams averaged 70%. Data on all study sites were recorded at that time. During 1963, data on all study sites were recorded when utilization of the grasses on the main drainages along streams reached 35, 70, and 90%.

Because of the expense involved the data for 1964 were not analyzed alone but were analyzed along with the other two years. The independent variables were factors believed to influence utilization of mountain slopes by cattle and the dependent variables were measures of degree of utilization on the study plots.

During 1962, 21 independent and 5 dependent variables were measured with respect to each of the 222 study sites. During 1963 and 1964 the same 21 independent variables were measured, but only 1 of the 5 dependent variables was measured.

Results and Discussion

In order to evaluate degree of use on sloping terrain, 5 common methods of determining utilization were recorded on all study plots at the end of the grazing season during the first year of study.

Measures of Utilization.—Correlation coefficients were determined among the 5 methods of measuring utilization (Y_1) weighted percent use of palatable species on the study sites, (Y_2) weighted percent use of all species on the study sites, (Y_3) average percent use of all species on the study sites, (Y_4) average percent use of all grass species on the study sites, and (Y_5) number of cow chips/100 ft diameter plot on the study sites.

$r_{Y_1 \cdot Y_2} = .665$	$r_{Y_2 \cdot Y_4} = .738$
$r_{Y_1 \cdot Y_3} = .643$	$r_{Y_2 \cdot Y_5} = .512$
$r_{Y_1 \cdot Y_4} = .865$	$r_{Y_3 \cdot Y_4} = .786$
$r_{Y_1 \cdot Y_5} = .329$	$r_{Y_3 \cdot Y_5} = .233$
$r_{Y_2 \cdot Y_3} = .714$	$r_{Y_4 \cdot Y_5} = .355$

All correlation coefficients were statistically significant except for (Y_5) number of cow chips per plot, which was not significantly correlated with any of the other utilization measures.

In the present study, cattle grazed only moderately on some slopes and saddles, yet traveled over the area many times and left many chips that were not proportionately related to percent use of the forage. Likewise, cattle were found to occupy some areas for considerable periods of time during the middle of the day but spent little time grazing. The number of chips counted on these areas indicated more grazing than actually occurred. On areas where the forage supply was abundant chips were often numerous but use of the herbage was only moderate. On other areas where the forage was sparse, a relatively small number of chips were present yet the forage was heavily used. Thus, it was concluded that cow chip counts on an area were unreliable indexes to daily forage intake or relative use of forage on the range. At best, chip counts for cattle merely suggest the relative time spent on various areas of the range.

Other studies have indicated that cattle defecate about 12 times per day (Johnstone-Wallace and Kennedy, 1944; Julander, 1955). In the study by Julander (1955) it was stated that cow chips were concentrated at watering places, salting grounds and bed grounds, and were not necessarily distributed proportionately where livestock fed.

Average percent use of the grasses was considered the best

measure of actual use since it had the highest correlation with other measures of utilization and was least time consuming.

Factors Affecting Utilization.—The main factors affecting utilization of mountain slopes were analyzed statistically as independent variables in a multiple regression problem. When the 21 independent variables measured in 1962 were analyzed by a step-wise regression procedure with each of the 5 dependent variables, only 11 of the 21 were found to have a significant effect upon more than one of the measures of utilization (Table 1). The independent variable percent slope at site (X_1), significantly affected all measurements of utilization. Percent use on slope adjacent to bottom below (X_{18}), significantly affected 4 of the 5 measures of utilization. Thickness of brush at site (X_{10}) was a significant factor affecting use on the study sites as expressed by 3 of the dependent variables (Table 1).

The 1963 data were analyzed by the same procedure used for the 1962 data, except that only one method of determining utilization was used—average percent utilization of grass species on the site. Utilization determinations on the 222 sites were made when grasses on bottom lands were used at 35%, when bottom lands were used at 70%, and when bottom lands were used at 90%. The data showed that 6 of the 11 most important variables affecting utilization of slopes shown in Table 1 were the same when bottom lands were used at 35, 70, and 90%. These variables were: Percent use of slope adjacent to bottom land (X_{18}), percent maximum slope from site to water (X_7), percent slope from water to salt across the site (X_{14}), percent slope from site to salt (X_{12}), percent use on valley bottom immediately below site (X_{19}), and percent slope at site (X_1).

Analysis of the influence of all 21 independent variables on the use of the slopes during 1963 showed that only 55.9, 51.3 and 50.3% of the variability of the dependent variable (Y_4) could be accounted for when the bottom lands were used to 35, 70 and 90%, respectively.

Mueggler (1965) in a study on mountain bunchgrass range in southwestern Montana found that percent slope and distance up slope from water accounted for 81% of the variation in actual use of a slope as determined by cow chips. These factors were of great importance in his study because the study sites were selected where there was always a uniform slope away from water below.

The 11 most important independent variables identified in 1962 and 1963 were among the 12 most important independent variables in the data for all three years combined (Table 2). These factors were:

(X_1) % slope at study site

(X_2) % slope adjacent to water below site

(X_3) % slope from site to water below

(X_4) Distance to water

(X_7) % maximum slope between site and water below

(X_9) % floral composition composed of high palatable plants on site

(X_{10}) % thickness of brush on and immediately around site

(X_{12}) % slope from site to salt above

(X_{14}) % slope from salt to water across site

(X_{18}) % use of grasses on slope adjacent to water below

(X_{19}) % use of grasses in drainage bottom directly below site

Five of these factors dealt with slope at site or slope between site and water. Therefore, a single measure of slope is not adequate for evaluating the influence of slope upon utilization of sloping terrain.

Distance from water of course affected utilization of the study site in a negative manner (Table

Table 1. List of the eleven most important factors affecting utilization of mountain slopes. An "S" under the methods of determining utilization indicates they significantly affected utilization of slopes by cattle during 1962.

Independent variables	Dependent Variables					
	Weighted % use of palatable species Y_1	Weighted % use of all species Y_2	Avg. % use of all species Y_3	Avg. % use of all grasses Y_4	No. chips per 100′ dia. plot Y_5	No. of measurements significant
X_1 % slope at site	S	S	S	S	S	5
X_2 % slope adj. to H_2O below	S	—	—	S	—	2
X_3 % slope, site to H_2O	—	S	—	S	—	2
X_4 Min. distance to H_2O	S	—	—	S	—	2
X_7 Maximum slope, H_2O to site	S	S	—	—	—	2
X_9 % high pal. plants on site	—	—	—	S	S	2
X_{10} Thickness of brush at site	S	—	S	S	—	3
X_{12} % slope, site to salt	S	—	—	S	—	2
X_{14} % slope, H_2O to salt	S	—	—	S	—	2
X_{18} % use slope adj. bottom	S	S	—	S	S	4
X_{19} % use on bottom below	S	—	—	S	—	2

Table 2. Averages, partial regression coefficients, and determination of regression coefficients for 21 independent variables and the dependent variable Y_4 (average percent utilization of all grass species on the study site). Data were collected in 1962, 1963 and 1964 when grasses on river bottoms were used 70%.

Variables[1]	Ave.	Partial regression coefficient		Det. of regres. coeff. $R^2 \times 100$
Constant (a)		20.7	33.27	
X_1 % slope at site	28.3	−.308	−.303	14.0
X_{18} % use slope adj. to bottom	38.4	.164	.165	23.2
X_3 % slope from site-H_2O	21.9	−.405	−.288	29.2
X_{19} % use on bottom below	54.5	.216	.177	32.0
X_9 % palatable plants on site	17.9	.218	.362	33.7
X_{11} % browse on site	47.3		−.131	34.8
X_{21} % use around H_2O below	70.9		.080	35.3
X_7 % maximum slope, H_2O-site	33.2		−.195	35.9
X_{10} Thickness of brush at site	3.6		−1.350	36.3
X_2 % slope adj. to H_2O below	23.1		−.082	36.6
X_{12} % slope, site-salt	11.3		.141	36.7
X_4 Distance to H_2O below-ft	1194.0		−.462	36.8
X_5 % minimum slope to H_2O	16.5		−.045	36.9
X_{13} Distance to salt-ft	1516.0		.003	36.9
X_{15} Dist. H_2O-salt across site	2718.0		−.002	37.1
X_6 Dist. with min. slope-H_2O	1522.0		−.001	37.3
X_{14} % slope, H_2O-salt	25.4		−.033	37.4
X_{17} Size of site	10.6		.024	37.4
X_{20} % grass on site	31.6		.321	37.4
X_8 % forbs on site	21.3		−.302	37.5
X_{16} Down timber at site	4.2		−.091	37.5
Y_4 % util. of grasses at site	19.4			
$s_{y.x}$ Standard error of estimate		10.3	10.0	

[1] Observations were made on 666 plots

2). The greater the distance from water the less the area was utilized generally. Thickness of brush around the study site affected the dependent factor in a negative manner by reducing utilization of the area. All independent factors dealing with percent utilization of bottom lands, adjacent slopes, etc., affected utilization on the study sites in a positive manner.

As would be expected, all independent factors concerned with increased percent slope affected the dependent factor in a negative manner except percent slope from site to salt (X_{12}). In this case, the relationship was positive. Cattle made use of all salt locations but when topography was steep they made less frequent visits to the salt. As a result they remained on the more gentle terrain below the placement of salt until a more demanding urge for salt motivated them to climb steeper range. Actually when animals left water below the study sites, where steep slopes above sites prevailed, they may have been drawn in the direction of the study area by salt but were more often content to graze up the slope only part of the way than to continue up steeper slopes for salt.

An analysis of the 21 independent variables for 1962, 1963, and 1964 (Table 2) showed that 9 of the 21 independent variables had a significant effect upon utilization of mountain slopes. These are shown in Table 2 in the order of relative importance.

Interaction Effects. — Range managers frequently try to evaluate the effect of slope alone as though other factors did not exist. Likewise, water is often credited with being the sole factor influencing range utilization as though all surrounding terrain were level and other factors were of little consequence.

In the present study it was found that many factors affect the utilization of mountainous terrain. Furthermore these factors are interrelated and they influence the use on a mountain slope in a most complicated manner.

The relationships between the independent variables and the dependent varible, average % utilization of grasses on the site, were linear in most respects; however, some interactions were believed to be important in explaining the variability in the use of mountain slopes. Therefore, all possible 3-way interactions were graphically analyzed, using the 11 independent factors two at a time with Y. This analysis showed that a few simple interactions were of value in explaining the variation in Y when all three years of data were analyzed.

The interactions % slope at site with % maximum slope between site and water ($X_1 \cdot X_7$), the % slope adjacent to water below with % maximum slope between site and water ($X_2 \cdot X_7$), X_1 with X_3 which represent % slope from site to water, and X_1 with X_2 show that each factor in each case complements the other in their effect upon utilization of mountain slopes. All slope measurements act in a negative manner upon use of slopes when considered as single factors or as combined effects.

An analysis of the interacting effect of % slope from site to water with distance from water ($X_3 \cdot X_4$) shows that as percent slope decreases distance from water becomes of greater significance in affecting utilization on mountain slopes.

The interaction % use of bottoms below site and thickness of brush around site ($X_{19} \cdot X_{10}$) pre-

sented a positive influence on Y. This was the result of use of bottoms below the site being more influential on the utilization of slopes than thickness of brush around site. After use of bottoms reached 50%, reduction in thickness of brush became more effective in increasing utilization on slopes.

The interaction of distance to water and % use of bottom ($X_4 \cdot X_{19}$) affected Y in a positive manner because of the greater influence of X_{19}, which alone affected Y in a positive manner. It was shown in this interaction that distance to water was more influential after bottoms were used 50%.

The interaction % palatable plants on site with thickness of brush around site ($X_9 \cdot X_2$) showed that as abundance of palatable plants decreased on the site thickness of brush around site became of greater importance in determining the utilization on mountain slopes. The interacting effect of distance from water with thickness of brush around site ($X_4 \cdot X_{10}$) suggests that as thickness of brush decreases distance from water becomes of greater importance in determining utilization on sloping terrain.

Estimating Utilization on Mountain Slopes. — The regression equation using 5 variables from Table 2 for an estimate of use (Y) that might be made on a particular slope on a mountain range would be:

$$Y = a + bX_1 + bX_3 + bX_{19} + bX_9$$

or

$$Y = 20.7 - .308\,X_1 + .164\,X_{18} - .405\,X_3 + .216\,X_{19} + .218\,X_9$$

The standard error of estimate $s_{Y.X}$ was approximately 10 for all quantities of variables suggested in Table 2.

It appears impractical to calculate the utilization a particular mountain slope might receive by livestock because of the wide confidence interval of predictability. This study suggests that the utilization expected on a mountain slope can best be determined by actual grazing under good management where livestock are drifted frequently and salt and water are appropriately located to attain good livestock distribution.

Conclusions and Summary

The average use of grasses by cattle on mountain slopes which ranged from 5 to 55% was 19.4%. The grazing use depends upon many interacting factors. Even when all 21 major factors believed to affect use of rough mountain terrain were included in the analyses only about 37 to 55% of the variability in utilization could be accounted for. The size of the standard error of estimate ($s_{Y.X}$) of 10% suggests that predicting use on a particular slope even when considering all 21 independent variables, would present an unreasonably wide confidence interval of the estimate. The answer to why animals do or do not graze mountain slopes may depend rather substantially on animal psychology.

Only 11 of the 21 independent variables studied signficantly affected utilization when the data were analyzed as a linear regression relationship. The most important were:

1. % slope at site
2. % slope adjacent to water
3. % slope from site to water
4. Distance to water below
5. % maximum slope between site and water
6. % palatable plants on site
7. Thickness of brush around site
8. % slope from site to salt

No one factor could be used as a reliable index to predicting use. Further, no single measure of percent slope adequately evaluated the influence of slope upon utilization of rough topography.

It is concluded that (1) actual use obtained under good management is the most accurate method of determining the utilization obtainable on a particular mountain slope and (2) the grazing capacity of a mountain range can be determined only on the basis of actual use obtained on sloping topography under good management practice.

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