1971-05-07

# An analysis of cattle grazing on steep slopes

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# AN ANALYSIS OF CATTLE GRAZING ON STEEP SLOPES

A Thesis

Presented to the

Department of Botany and Range Science

Brigham Young University

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

by

W. Wayne Patton

May 1971

## ACKNOWLEDGEMENTS

Much appreciation is extended to Dr. Odell Julander for serving as chairman of my advisory committee and offering helpful suggestions and advisement during this study. I also express thanks to Dr. Joseph R. Murdock and Dr. R. B. Farnsworth for serving on the committee and reviewing the thesis.

Appreciation is extended to Vern J. Crandall for help with the computer analysis problems. Appreciation is also extended to personnel of the Sawtooth National Forest for their help. I express thanks to Cheryl Patton.

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# INTRODUCTION

Methods of increasing range forage utilization by cattle have become increasingly important in recent years. One such method now being used on western rangeland is the rest-rotation system. This system specifies heavy seasonal livestock utilization in a unit followed by a complete rest, usually during the following year.

The rest-rotation system is based on the assumption that heavy concentrations of grazing animals will make more uniform use of forage over a larger percentage of the range (Hormay and Talbot 1961). Maximum sustained livestock production can be obtained with more uniform utilization.

On steep cattle range attaining uniform forage utilization is always a problem. Although a 30-percent slope is a generally accepted limiting factor on steep cattle range, cattle do graze on much steeper slopes. Cattle will not walk straight up slopes much steeper than 30 percent as has been proven by previous research, but observations made on a pasture under the rest-rotation system show they will walk up a watercourse and then contour on the level out onto slopes approaching 65 to 70 percent where they utilize forage to some extent.

The main objectives of this study are to determine the effects of (1) water location, (2) salt location, (3) kind and amount of forage, and (4) steepness of slope on the distribution and range use of cattle under the rest-rotation system as practiced on the mountainous Gooding

Pasture Allotment. The field work on this project was carried out during the years of 1969 and 1970 on the Sawtooth National Forest in Idaho.

# LITERATURE REVIEW

Obtaining uniform livestock distribution on steep cattle range is a major management problem. Research in this area has been limited to season-long grazing units.

Walter Mueggler (1965) concluded that livestock use is inversely proportional to slope steepness for Montana ranges. This study was based on cow-chip counts taken from fourteen-foot-wide transects extending 150 yards along the slope contour. The study areas used by Mueggler were accessible to cattle only from the bottom of the slope.

From a study based on forage utilization taken from transects along the contour of the slope, Phillips (1965) arrived at the same conclusions as Mueggler. In Phillips' Idaho and Nevada study, carried out on two national forests, slope gradient was the major factor influencing the use pattern. Decrease in utilization was noticed on steep slopes. Intensity of use in canyon bottoms did not increase utilization on adjacent steep slopes. Distance from water was the second major factor affecting the livestock utilization pattern. Utilization was found to decrease the first 10 chains from water and reach zero near 100 chains from water. Localized areas near salt and shade were heavily utilized but this effect was minor compared to the overall effect of slope gradients and distances from water.

Cook (1967) in a Utah study on the Cache National Forest found eight independent variables which affected utilization as shown by linear regression analysis. These were (1) percent slope at site, (2) percent slope adjacent to water, (3) percent slope from site to water, (4) distance to water below, (5) percent maximum slope between site and water, (6) percent palatable plants on site, (7) percent thickness of brush around site, (8) and percent slope from site to salt. No one factor was found to be a reliable index for predicting use. Animal psychology was believed to be responsible for the intensity of cattle use on steep slopes. According to Cook the grazing capacity of a mountain range can be determined only on the basis of actual use obtained on sloping topography under correct management practice.

In central Utah, cattle distribution was influenced mainly by steepness of slope and availability of water and forage (Julander 1955) (Julander and Jeffery 1964). This study was based on use data collected on transects that were located across the study area at right angles to secondary drainages.

More uniform livestock distribution on gentle topography can be obtained with the use of the rest-rotation system. This management plan is based on the assumption that heavy concentrations of grazing animals will force more uniform use of forage plants over a high percentage of the range. Heavy use one year would be followed by a grazing-free year of rest during which the forage plants would be permitted to renew their food supplies and life functions (Hormay and Talbot 1961).

Cleary (1971) reported increased in grazing capacity and improved watershed conditions as well as increased cattle conception rates under the rest-rotation system as compared to the season-long grazing system.

From a study on the Gooding Cattle Allotment in Idaho, Little (1971) reported improved cattle distribution under the rest-rotation system with good forage utilization on slopes up to 45%. Cattle made better gains than had been previously recorded under season-long grazing and utilized more of the less palatable plants. Three major influences noted were gully healing, increase of litter, and an increase in forage production.

Conclusions made from this literature review indicate a general agreement among authors concerning the importance of slope, distance from water and salt, as well as the type of forage present on the slopes. However, a study correlating cattle grazing patterns on steep terrain with the rest-rotation system has not been made. Neither has the effect of the use of cattle contour trails on the effect of cattle use of steep slopes been evaluated.

## LOCATION AND DESCRIPTION OF STUDY AREA

The study area is in Idaho, twenty-five miles northeast of Fairfield in the Gooding Cattle Allotment of the Sawtooth National Forest. The allotment consists of approximately 38 sections of steep hill country ranging in elevation from 6,500 to 8,200 feet. The area receives a rainfall range of 16 to 24 inches annually. Topography is steep with slopes ranging from 20% to 75% (Fig. 6). Vegetation is primarily of the sage-grass, mountain brush-grass and pine-grass types. The average yearly forage production taken from a ten-year Forest Service study is 896 pounds per acre dry weight (Phillips 1970).

The soils are derived from andesite parent material from the Challis Volcanic geologic formation with small areas of soil being derived from quartz monzonite of the Idaho batholith. The soil texture varies from gravelly loam to stony loam with a pH of about 7.5.

The Gooding Cattle Allotment was grazed season-long until 1965 when it was developed into a four-pasture rest-rotation system (Table 1). A total of 535 head of cows and calves are grazed for a total of 1786 animal unit months each season.

Two canyons (study areas) are secondary drainages in the headwaters of Red Rock Creek and one is in the headwaters of Williams Creek. These study areas are each approximately one and one-half miles long and one-half mile wide (Figs. 1, 2, 3, 4 and 5). These canyons, in grazing units 3 and 4 respectively, were grazed heavily to obtain the maximum

Table 1. The rest rotation grazing plan of the Gooding Cattle Allotment (grazed by a herd of 535 head of cattle.)

| Year | Unit 1 | | Unit 2 | | Unit 3 | | Unit 4 | |
|---|---|---|---|---|---|---|---|---|
| | Dates | A.U.M.S. | Dates | A.U.M.S. | Dates | A.U.M.S. | Dates | A.U.M.S. |
| 1969 | .....Rest...... | | 9/15-10/1 | 267 | 7/10-8/15*<br>10/2-10/20 | 984 | 8/16-9/15 | 535 |
| 1970 | 10/2-10/20 | 358 | 1/2-10/1 | 535 | .......Rest....... | | 7/10-9/1** | 893 |
| 1971 | 7/11-10/2 | 359 | 7/10-9/10 | 1070 | 10/2-10/20 | 358 | ......Rest........ | |
| 1972 | 7/10-9/11 | 893 | ......Rest...... | | 9/2-10/1 | 535 | 10/2-10/20 | 359 |

*The treatment of Unit #3 studied in early September 1969

**The treatment of Unit #4 studied in early September 1970

Fig. 1. Aerial view of canyons one and two--unit 3.

Fig. 2. Aerial view of canyon three--unit 4.

possible forage utilization before the studies were made during the summers of 1969 and 1970 (Table 1).

Fig. 3. Canyon number 1.

Fig. 4. Canyon number 2.

Fig. 5. Canyon number 3.

Fig. 6. Gooding Pasture Allotment.

# METHODS AND PROCEDURES

Each of three canyons (study areas) were divided into quarter-mile segments. Each segment was divided into five sampling units, each extending at right angles to the drainage and extending from ridgetop to ridgetop (Figs. 13, 14 & 15). Two sampling units per segment were chosen at random for the position of a transect. This type of restricted random sampling gives a better distribution pattern for the transects.

Line-plot transects were positioned across canyons from ridgetop to ridgetop at right angles to the slope. These transects were composed of 9.6 square foot plots spaced one chain apart. A map was made showing the position of each plot on an enlarged aerial photograph. The slope percentage was measured at each plot using an abney level.

Within the plots the weight of each plant was either measured or estimated and the percentage utilized by cattle determined using the ocular estimate-by-plot method (Pechanec and Pickford 1937). Plant weights were recorded by Forest Service classification (desirable, intermediate, least desirable) based on their value in the plant community (U.S.D.A. 1964). To check weight estimates of important forage, plants outside the plots were clipped to simulate grazing observed within the plots. The remaining stubble in the plot was clipped, both clippings were weighed, converted to air-dry weight, and the actual percentage weight removal was computed. The three species utilized the most in each of the 550 plots served as the basis for grazing intensity maps (Figs. 13, 14 and 15). These maps indicate the extent to which cattle make use of contour trails and adjacent forage.

The air-dry weights for each species of plant were used as a basis for calculating composition (Appendix A). The air-dry weight of each plant was divided by the air-dry weight for all plant species.

Soil disturbance estimates were based on the amount of animal-caused disturbance in each 9.6 foot plot. These disturbance data were used in determining the locations of animal travel for the grazing pattern maps (Figs. 13, 14 and 15). Dropping counts were made using a plot with a radius of 10.33 feet with its center corresponding to the center of the 9.6 square foot plots (Julander 1955).

All distances were measured in chains and were either paced off on the ground or plotted from an aerial photograph of known scale. Measurements were (1) distance from the water to plot, (2) distance from water to plot along the contour trail actually followed by the animals, (3) distance from salt to plot, (4) and distance from contour trail to plot. The actual contour trails developed by cattle were followed and mapped on the ground as a supplement to the grazing pattern map mentioned above. Some qualitative observations were made on the grazing impact made by cattle on the soil and vegetation.

Data were subjected to an analysis of variance to determine the effects on utilization of steepness of slope, soil disturbance, droppings per acre, distance from water to plot airline distance, distance from salt to plot, and distance from water to plot along the contour trail. In a similar manner, the effects of the kinds of forage plants on utilization were evaluated. The F test was used as the basis for deciding significance. Significance values having a 95% confidence interval are designated by (*) (Appendixes B & C). Highly significant values having a 99%

confidence level are designated by (**).

# RESULTS AND DISCUSSION

## Effect of Contour Trails

Results show as indicated on the utilization maps (Figs. 13, 14 and 15) definite cattle grazing patterns. Cattle walk up the sloping stream course (20-30% slope) in the canyon bottom to a water source. They then feed along contour trails on both sides of the canyon. The animals utilize heavily the canyon bottoms and the ridgetops. This is to be expected since they are natural congregating areas. Water and accessibility in the bottoms and salt and shade on ridgetops tended to hold the animals in these areas. Utilization percentages of 75 to 90% were recorded in the bottoms and 40 to 60% on the ridgetops. The utilization pattern was much more patchy and sporadic on the steep faces of the canyons. Heavy utilization extended from one to two chains and not more than four chains from the center of a contour trail. These distances varied with the forage type and also grazing pressure. Thick brush and downed timber limited the movement of cattle upslope and downslope from the contour trail. Heavy grazing pressure widened the contour trails. The origin of contour trail appears to fix the position of the entire contour trail. Cattle will, however, zig-zag for short distances up slope to get around obstacles such as downed trees.

Factors affecting utilization of mountain slopes were analyzed statistically as independent variables in a series of regression problems. The independent variables significantly affecting utilization in descending order are (1) percent slope at site, (2) distance from water to site along the cattle contour trails, (3) distance from water to site, (4) and distance from salt to site. The amount of desirable plants, pounds per acre dry weight, in each plot also significantly affected utilization. The least desirable and intermediate plants had a negative effect on utilization.

## Effect of Steepness of Slope on Utilization

Percent slope at site was found to have the greatest single effect on utilization of forage (Appendix B). Figure 7 illustrates the effect of percent slope on forage utilization by cattle.

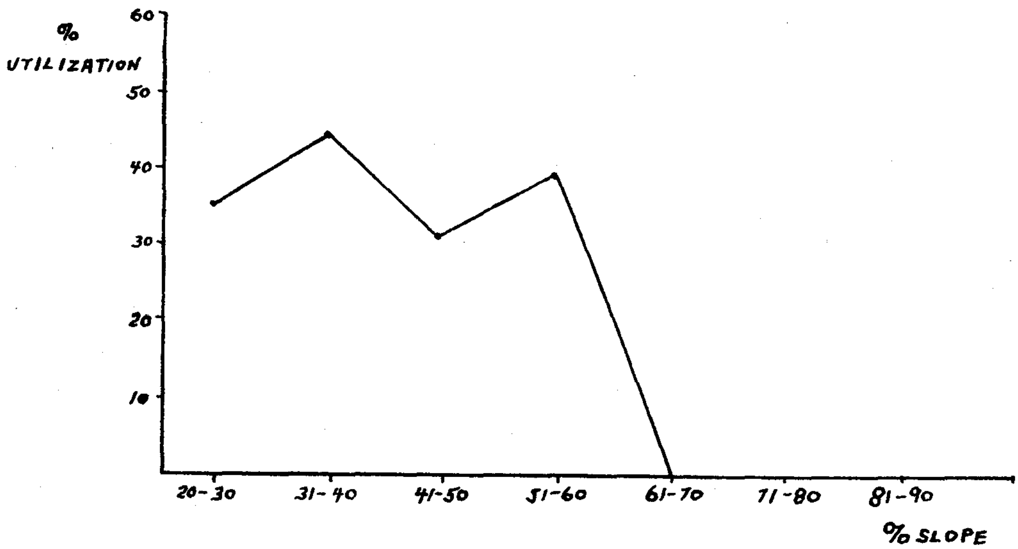



Fig. 7. The effect of slope on utilization.

Cattle utilize slopes between 20% and 60% quite heavily with the greatest impact on slopes less than 40%. The 60% slope seems to be the maximum used by cattle. No cattle grazing took place on the 61% to 80% slopes.

## Effect of Distance from Water Along the Contour on Utilization

Distance from water to site along the contour cattle trails had a highly significant effect on utilization of forage by cattle (Appendix B).

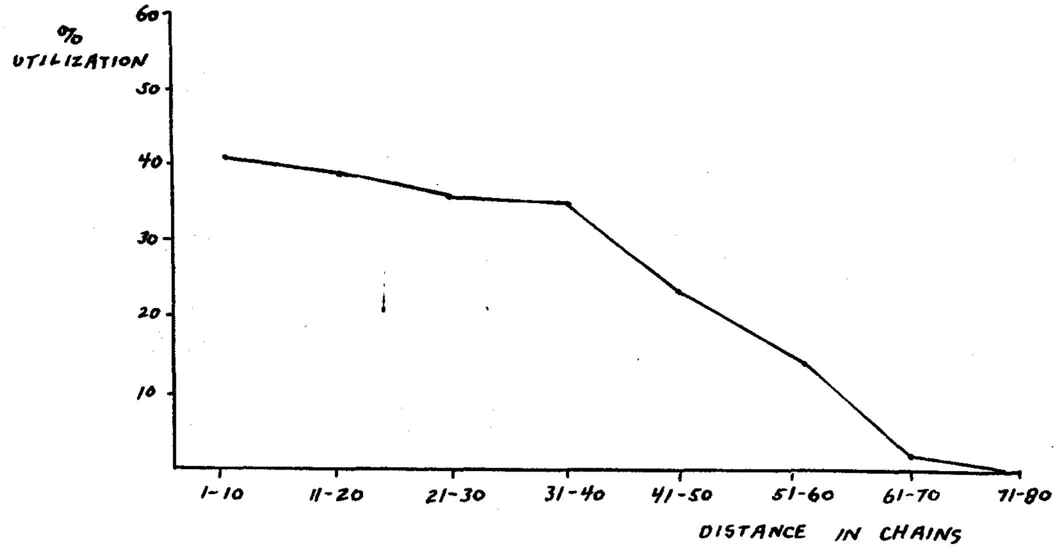



Fig. 8. The effect of distance from water along the contour to site on utilization.

Utilization decreased gradually with distance from water along the contour trails up to about 60 chains. Mean utilization starts to decrease rapidly beyond 60 chains until at 80 chains almost no utilization was observed (Fig. 8). This measurement is a good indicator of the degree of utilization to be expected.

Effect of Air-line Distance from Water on Utilization

Distance from water to site is also a good measure of expected utilization. As air-line distance from water increases utilization of forage by cattle decreases. The maximum air-line distance from water that cattle were found on the mountainous study area was 50 chains (Fig. 9). While being less accurate than distances from water along the contour this measurement is the easiest to make and can be done from aerial photographs.

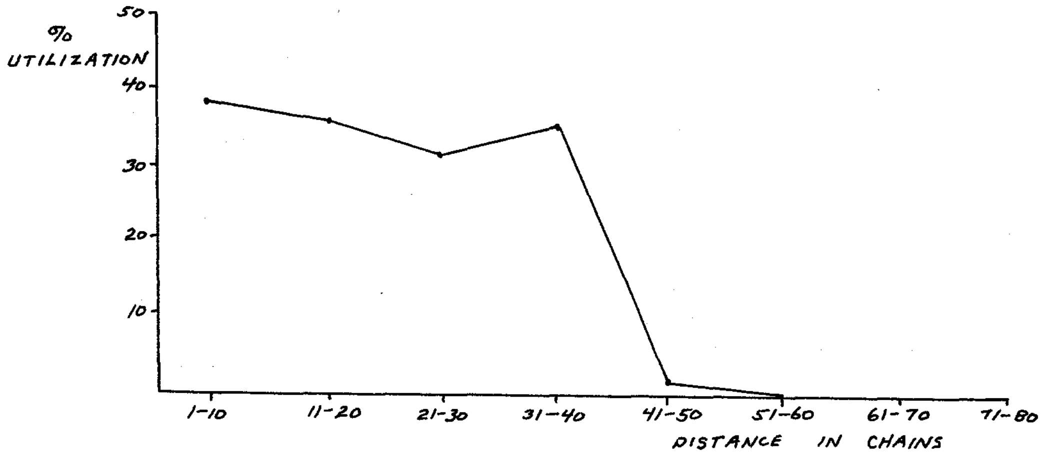



Fig. 9. The effect of distance from water to site on utilization.

Effect of Salt Location

Salt as placed on the ridgetops on the Gooding Cattle Allotment had a significant effect on utilization much the same as distance from water (Appendix B, Figure 10).

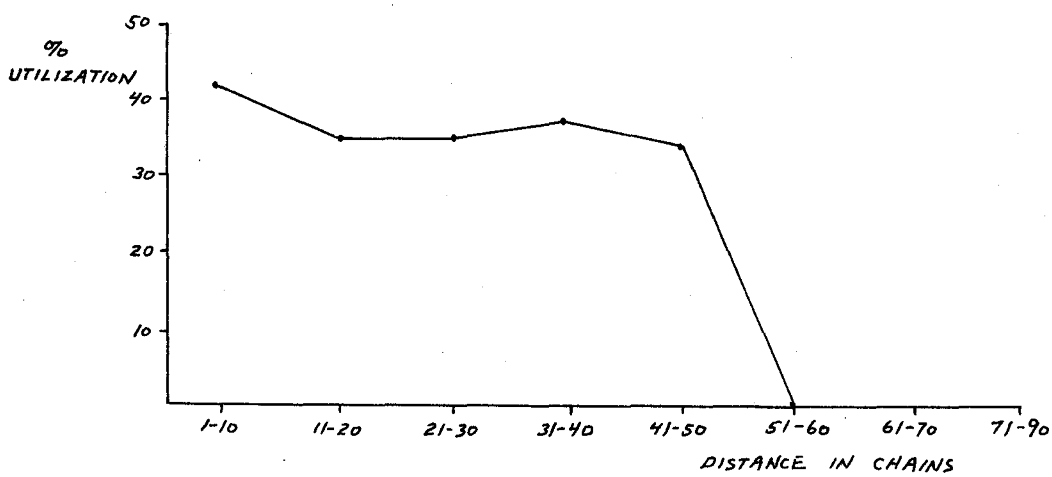



Fig. 10. The effect of distance from salt to site on utilization.

Forage utilization decreased rather slowly with distance from salt up to 60 chains and decreased rapidly with greater distances.

Relation of Forage Use to Soil Disturbance

Areas with high soil disturbance were closely associated with heavy utilization as would be expected (Figure 11).

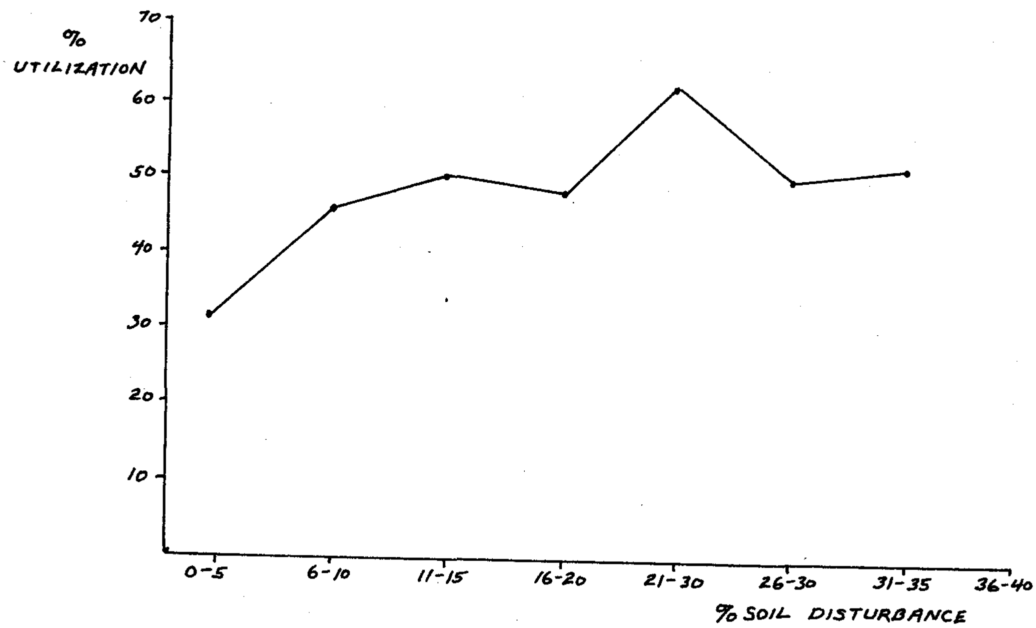



Fig. 11. The relation of forage use to soil disturbance.

## Relation of Forage Use to Cow Dropping Density

High cow dropping counts per acre were closely associated with heavy utilization as shown by a highly significant positive relation (Appendix B). Therefore a dropping count would be a useful measure of cattle use on steep cattle allotments. Cattle seek shade and spend a lot of time around water where they defecate (Julander 1955). However, very few of these areas were actually sampled by plots, hence this shortcoming of the method had little effect in this study.

## Effect of Type of Forage on Utilization

When considered together the dry weight per acre values of the three categories of plants (desirable, intermediate, least desirable) account for a considerable amount of the total variability of utilization of forage. Desirable, intermediate and least desirable weights were

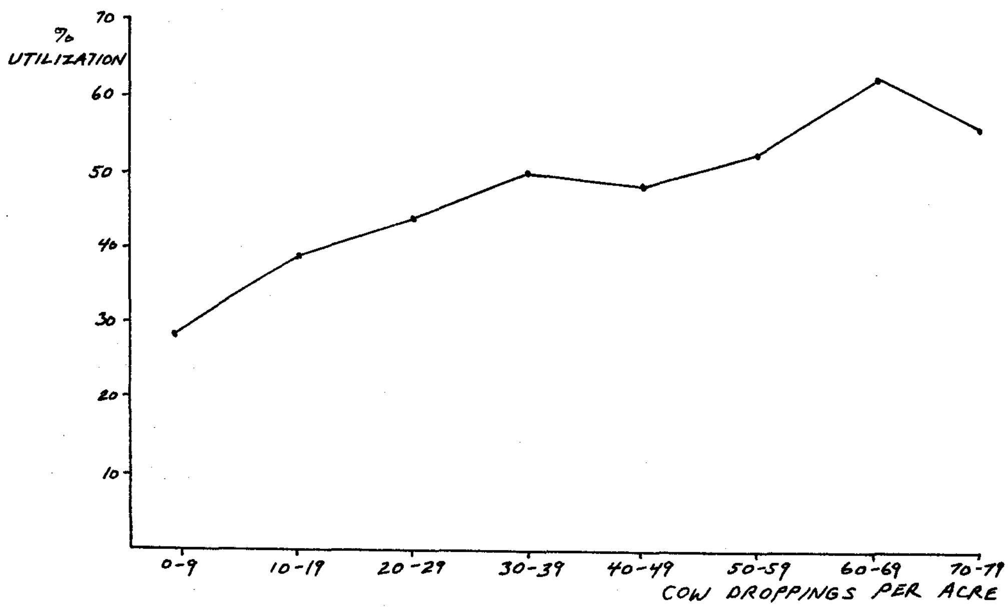



Fig. 12. The relation of forage use to cow dropping density.

based on the same units of measurement, therefore the coefficient of each can be used in the estimation of utilization.

This effect can be expressed mathematically in the following manner: $Y=B_0+B_1X_1+B_2X_2+B_3X_3$ where Y equals the average utilization across the entire sampling area, $B_1$, $B_2$, and $B_3$ equal the weight of effect each plant category has on forage utilization, and $X_1$, $X_2$ and $X_3$ equal the respective amounts in pounds per acre dry weight of each of the three plant categories. When the values obtained in the study are incorporated into this formula interesting conclusions can be drawn as indicated below.

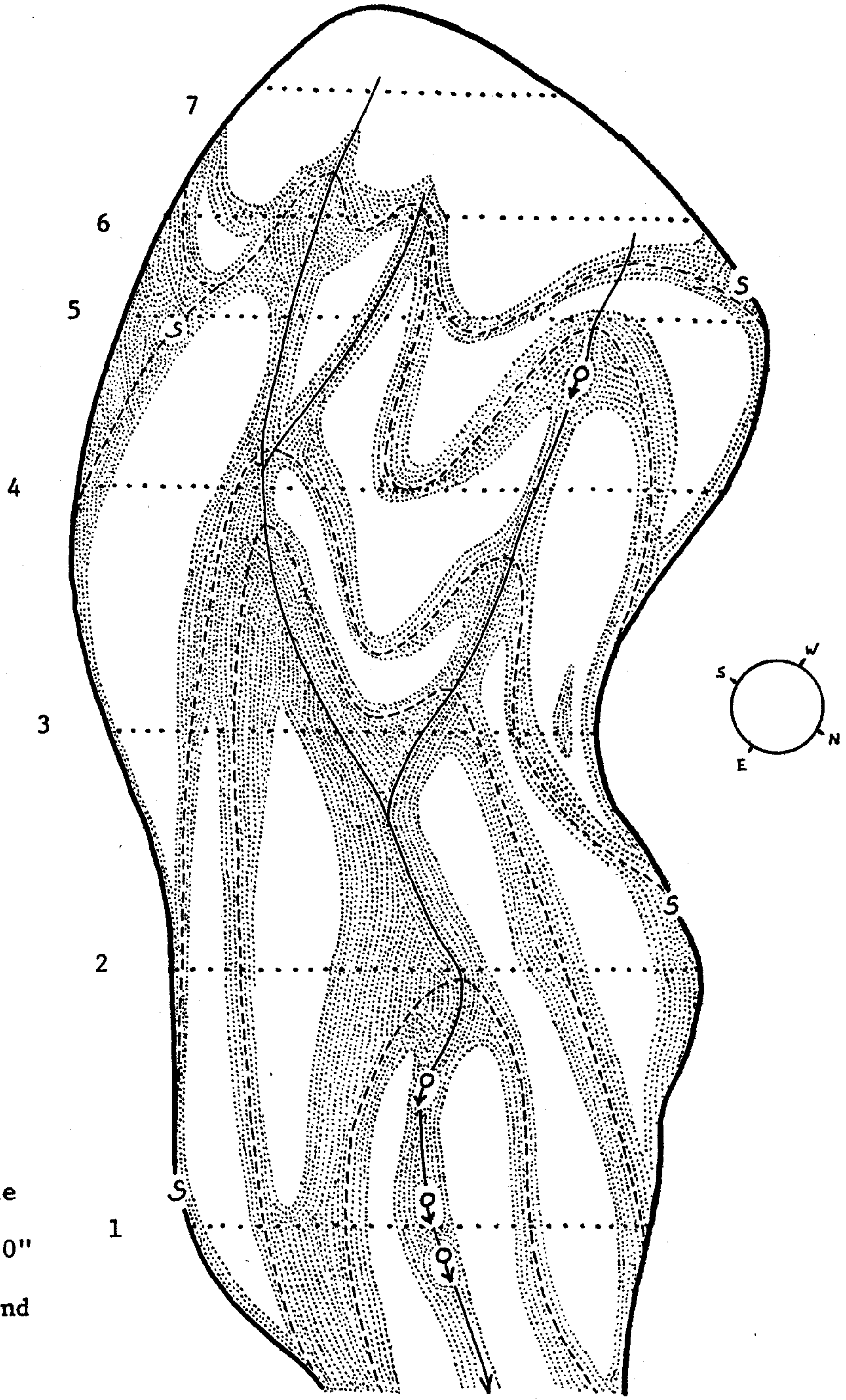
Utilization=35.164+0.018 (desirable plant weight)-0.047
(intermediate plant weight)-0.023 (undesirable plant weight)

The number 35.164 represents the average utilization taken from the study data. The intermediate plant category has the greatest effect on forage utilization, 0.047, and the effect is negative. The desirable plants have a fairly small positive influence, 0.018, and the least desirable plants have a small negative effect, 0.023, on forage utilization. Large concentrations of intermediate and least desirable plants (for example *Lupinus* spp. and *Artemisia tridentata*) were dense to the exclusion of the desirable grasses (*Agropyron spicatum inerme* and *Festuca idahoensis*) (Appendix A). Cattle did utilize intermediate plants to some extent but not as much as the desirable forage.

The grazing pattern maps show wide ungrazed areas between contour trails (Figs. 13, 14 and 15). If transects are run parellel to the contour they could easily fall in an ungrazed area thereby weighting the outcome. Pure random placement of quadrats similar to those used by Cook (1967) is in theory the least biased sampling technique. However, time and effort required to take the large number of purely random sample needed in this study was prohibitive in addition to the possibility of missing a plot location due to rough terrain. Restricted random methods of locating transect positioned across canyons were found to be the most sensitive indicator of forage utilization. Restricted random sampling also ensures better distribution of plots.

As cattle are forced by heavy utilization in canyon bottoms to steeper slopes the contour grazing effect becomes more important. Animals walk from a watering location along the easiest route to forage or salt. The three most heavily used desirable plants were utilized 25 percent and more over 45 percent of the total area studied (Table 2). Downed trees were observed to cause gaps in utilization as cattle walked around the upper and lower ends of the obstacle. Removal of such obstacles could add a substantial amount of animal unit months to a mountain range.

As previously mentioned watering locations regulate the positions



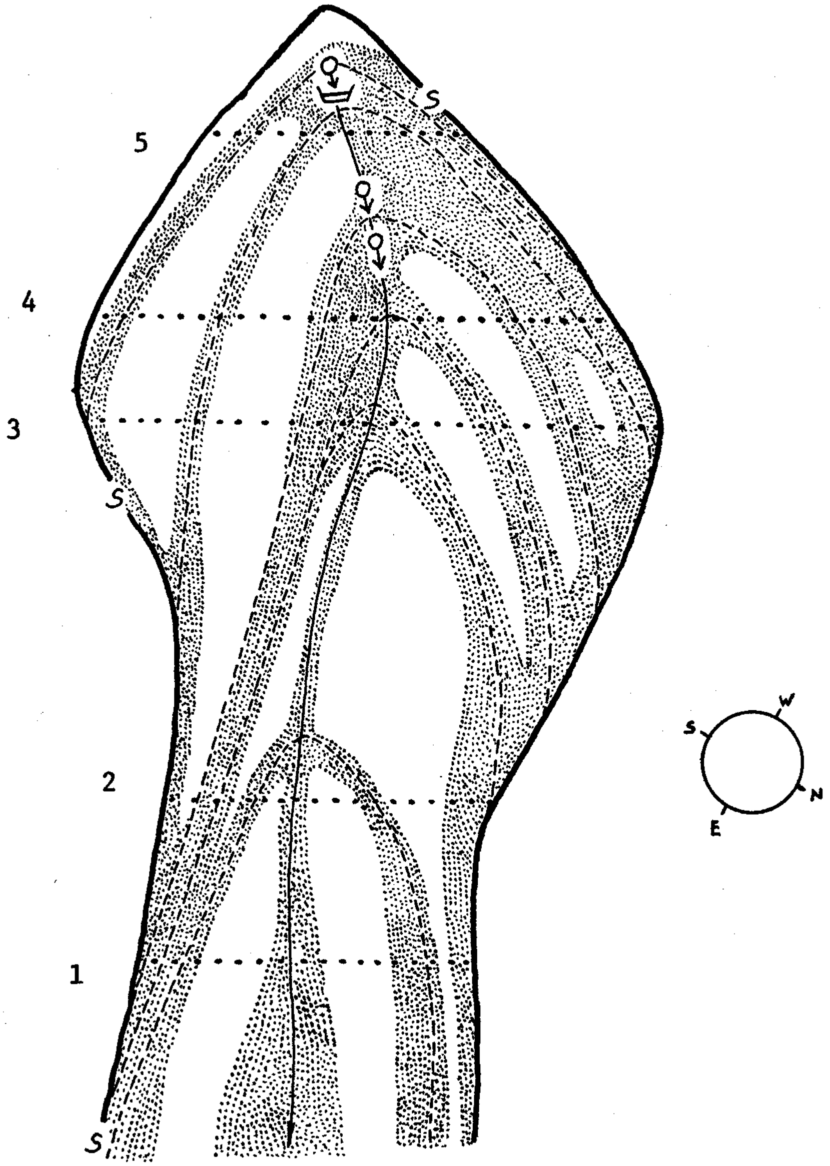

Scale

1" = 7,920"

Legend

o→ Spring
S Salt
• • Study plots
▬ Canyon boundary
▒ 25% utilization
By cattle

Fig. 13. Grazing pattern in canyon 1.




Scale

1" = 7,920"

Legend

O→ Spring
S Salt
Watering trough
··· Study plots
— Canyon boundary
25% utilization
By cattle

Fig. 14. Grazing pattern in canyon 2.

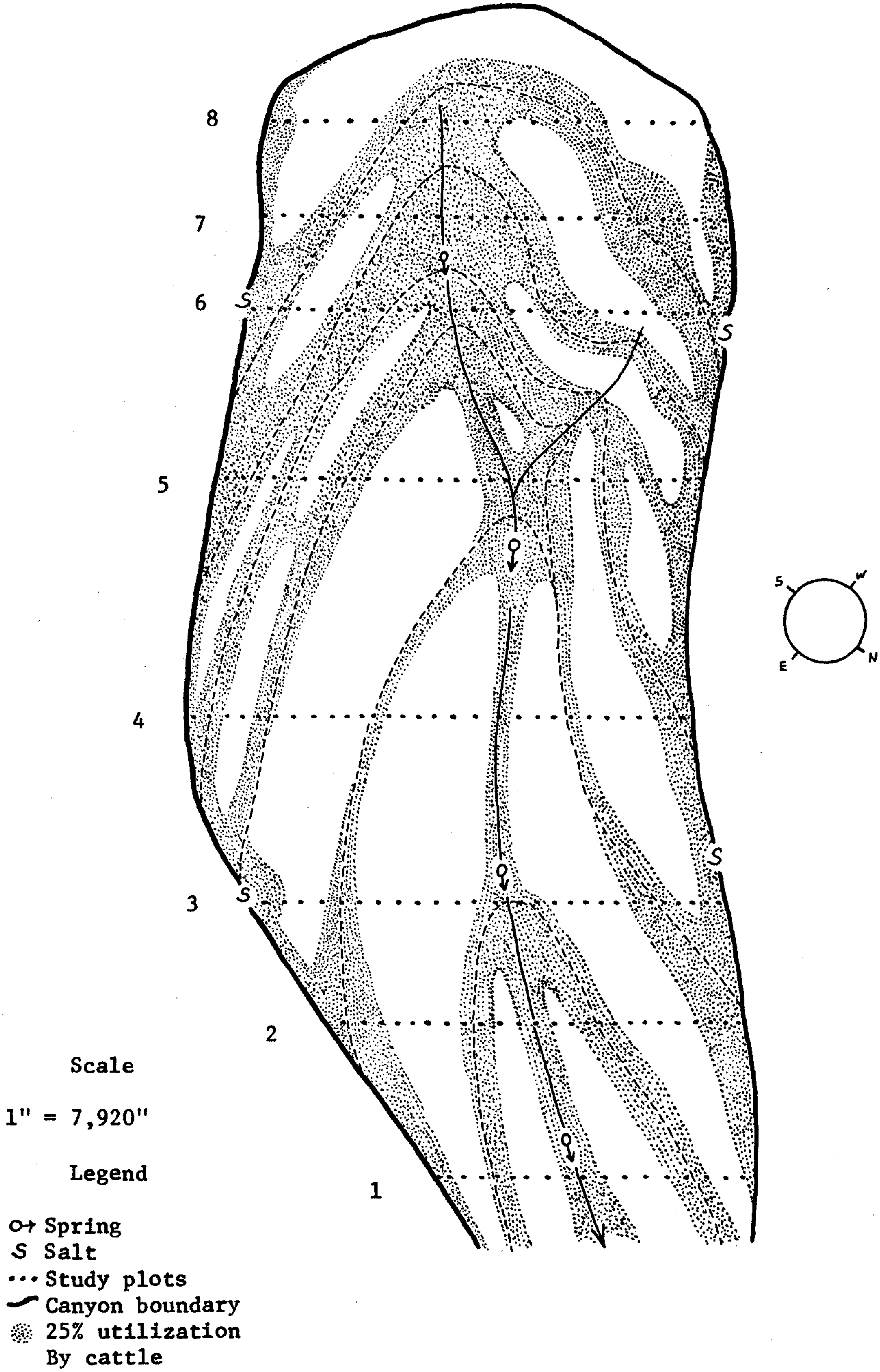



Fig. 15. Grazing pattern in canyon 3.

of contour grazing trails used by cattle. Piping water down canyons to areas adjacent to ungrazed strips of forage along the contour could open up new contour trails thereby adding animal unit months to an allotment. Observation can determine potential watering locations using the presence or absence of livestock contour trails in canyons.

Salt should be placed near but not along heavily utilized contour trails. Placement in this manner will draw cattle from the contour trails up or downslope to forage thereby increasing the carrying capacity of the range.

Table 2. The acreages of the canyons and the acreages of the areas used 25% and over by cattle (from Figs. 13, 14 and 15).

| | Canyon 1 | Canyon 2 | Canyon 3 | Totals |
|---|---|---|---|---|
| Total acres | 217 | 119 | 222 | 558 |
| Acres used | 98 | 51 | 107 | 256 |
| Percent used | 45% | 41% | 48% | 45% |

# CONCLUSIONS

The rest-rotation system as practiced on the Gooding Cattle Allotment is resulting in good forage use as the animals are grazing forage on slopes up to 60%. Level contour trails extending across the slope faces made it possible for cattle to graze on steep slopes at distances up to 80 chains from water. Contour trails originate at watering locations; hence better distribution of water could be expected to result in better distribution of cattle on steep ranges. Downed timber effectively blocked some contour trails and its removal could increase forage utilization.

Independent variables significantly effecting utilization of forage were percent slope at site, distance from water to site along the contour, air-line distance from water to site and distance from site to salt. The presence of desirable forage plants positively affected forage utilization by cattle and the intermediate and least desirable plants had a negative affect. When combined these three categories of plants had a significant effect on forage utilization. Soil disturbance and dropping counts were found to be significant indicators of the intensity of use of range by cattle. Results suggest that the rest-rotation method can be used to obtain good forage utilization in steep-slope cattle allotments. More uniform use of steep range can be obtained by developing watering facilities in canyon bottoms adjacent to ungrazed strips on the canyon faces and by proper placement of salt.

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# APPENDIX A

DRY WEIGHT PRODUCTION IN POUNDS PER ACRE FOR CANYON #1

| SPECIES TRANSECT | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| GRASSES AND GRASSLIKES | | | | | | | |
| Agropyron smithii | 72 | 50 | 112 | 112 | 216 | 228 | 246 |
| Bromus marginatus | 2 | | 8 | 10 | 26 | 2 | 6 |
| Carex geyeri | 12 | 24 | 10 | 16 | 14 | 12 | |
| Elymus cinereus | | 4 | 16 | 12 | 26 | 86 | 68 |
| Festuca idahoensis | 134 | 162 | 70 | 18 | 40 | 12 | 24 |
| Koeleria cristata | | 10 | 2 | | | | |
| Melica bulbosa | | | | | 4 | | |
| Poa fendleriana | | | 4 | | 1 | | |
| Poa pratensis | 2 | 4 | | | | | |
| Poa secunda | 4 | | | 4 | | | |
| Sitanion hystrix | 2 | 4 | | | | | |
| Stipa columbiana | | | | | 4 | | 2 |
| Stipa lettermannii | | 4 | | | 6 | | |
| FORBS | | | | | | | |
| Achillea millefolium | | 8 | | | | | |
| Agastache urticifolia | | | | | 10 | 18 | 12 |
| Annual spp. | 4 | | 20 | 8 | 16 | 10 | 12 |
| Antennaria corymbosa | 2 | 6 | | | | | 4 |
| Arnica longifolia | | | | | 1 | 8 | 1 |
| Arabis spp. | | | 8 | 4 | | | |
| Balsamorhiza sagittata | | | | 14 | | | |
| Crepis acuminata | | | | 3 | 1 | 4 | |
| Eriogonum umbellatum | 10 | 18 | 24 | 3 | 4 | 4 | 10 |
| Geranium fremontii | | | | | 4 | | |
| Geum triflorum | | 4 | | | | | |
| Gilia aggregata | | | | | | 6 | |
| Hackelia floribunda | | | | | 18 | | 6 |
| Lupinus spp. | 10 | 8 | 4 | | | | 4 |
| Osmorhiza occidentalis | | 2 | | | | | |
| Phlox hoodii | 2 | 4 | | | | | 1 |
| Polygonum douglasii | | | 4 | | | | |
| SHRUBS | | | | | | | |
| Artemisia tridentata | 346 | 326 | 150 | 194 | 214 | 274 | 278 |
| Mahonia repens | | | | | | 1 | |
| Chrysothamnus nauseosus | | | | | | | 18 |
| Chrysothamnus viscidiflorus | 28 | 16 | 38 | 4 | 6 | 20 | 52 |
| Prunus virginiana | | | | | | 18 | 10 |
| Purshia tridentata | 20 | | | 14 | | 184 | |
| Rosa woodsii | | | | | 1 | | |
| Symphoricarpos oreophilus | | | 4 | 8 | 14 | 26 | 8 |
| TOTALS | 650 | 654 | 474 | 420 | 630 | 1022 | 954 |

COMPOSITION FROM DRY WEIGHT FOR CANYON #1

| SPECIES TRANSECT | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| GRASSES AND GRASSLIKES | | | | | | | |
| Agropyron smithii | 11 | 5 | 24 | 28 | 34 | 22 | 26 |
| Bromus marginatus | | | 2 | 2 | 4 | | 1 |
| Carex geyeri | 2 | 4 | 2 | 4 | 2 | 1 | |
| Elymus cinereus | | 1 | 3 | 3 | 4 | 18 | 7 |
| Festuca idahoensis | 23 | 23 | 15 | 4 | 6 | 1 | 2 |
| Koeleria cristata | | 2 | | | | | |
| Melica bulbosa | | | | | 1 | | |
| Poa fendleriana | | | 1 | | | | |
| Poa pratensis | | 1 | | | | | |
| Poa secunda | 1 | | | | 1 | | |
| Sitanion hystrix | | 1 | | | | | |
| Stipa columbiana | | | | | 1 | | |
| Stipa lettermannii | | 1 | | | 1 | | |
| FORBS | | | | | | | |
| Achillia millefolium | | 2 | | | | | |
| Agastache urticifolia | | | | | 2 | 2 | 1 |
| Annual spp. | 1 | | 4 | 2 | 2 | 1 | 1 |
| Antennaria corymbosa | | 1 | | | | | 4 |
| Arnica longifolia | | | | | | 1 | |
| Arabis spp. | | | 2 | 1 | | | |
| Balsamorhiza sagittata | | | | 3 | | 1 | 1 |
| Crepis acuminata | | | | 1 | | | |
| Eriogonum umbellatum | 2 | 3 | 5 | 1 | 1 | | 1 |
| Geranium fremontii | | | | | 1 | | |
| Geum triflorum | | 1 | | | | | |
| Gilia aggregata | | | | | | 1 | |
| Hackelia floribunda | | | | | 3 | | 1 |
| Lupinus spp. | 2 | 2 | 1 | | | | |
| Osmorhiza occidentalis | | | | | | | 21 |
| Phlox hoodii | | 1 | | | | | |
| Polygonum douglasii | | | 1 | | | | |
| SHRUBS | | | | | | | |
| Artemisia tridentata | 51 | 51 | 31 | 45 | 33 | 29 | 29 |
| Mahonia ripens | | | | | | | |
| Chrysothamnus nauseosus | | | | | | | 2 |
| Chrysothamnus viscidiflorus | 4 | 2 | 8 | 1 | 1 | 2 | 5 |
| Prunus virginiana | | | | | | 2 | 1 |
| Purshia tridentata | 3 | | | 3 | | 16 | |
| Rosa woodsii | | | | | | | |
| Symphoricarpos oreophilus | | | 1 | 2 | 3 | 3 | 1 |
| TOTALS | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

DRY WEIGHT PRODUCTION IN POUNDS PER ACRE FOR CANYON #2

| SPECIES TRANSECT | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| GRASSES AND GRASSLIKES | | | | | |
| Agropyron smithii | 36 | 48 | 164 | 146 | 172 |
| Agropyron trachycaulum | 12 | | | | |
| Bromus marginatus | | | | 4 | 12 |
| Carex geyeri | 20 | | 26 | 8 | 18 |
| Elymus cinereus | | | 6 | 68 | 42 |
| Festuca idahoensis | 94 | 72 | 46 | 56 | 14 |
| Koeleria cristata | 2 | 4 | | | |
| Melica bulbosa | | | | | 4 |
| Poa fendleriana | | 6 | 4 | 8 | 6 |
| Poa pratensis | 6 | | | | |
| Poa secunda | | 12 | | | |
| Stipa columbiana | | | 4 | | 8 |
| Trisetum spicatum | | | 4 | 2 | |
| FORBS | | | | | |
| Achillea millefolium | | | | 4 | |
| Annual spp. | 6 | 14 | 14 | 18 | 18 |
| Antennaria corymbosa | 2 | | | 2 | |
| Arnica cordifolia | | | | | 24 |
| Arabis spp. | 2 | | | 4 | |
| Aster spp. | 8 | 6 | 6 | 4 | 10 |
| Balsamorhiza sagittata | | | 24 | 4 | 6 |
| Calochortus nuttallii | 2 | | 2 | | |
| Crepis acuminata | | | 4 | 6 | |
| Eriogonum umbellatum | 6 | 16 | 18 | 6 | 18 |
| Geranium fremontii | | | 8 | 4 | |
| Hackelia floribunda | | | | 2 | 24 |
| Linum lewisii | | | | 2 | |
| Lupinus spp. | 6 | 10 | 2 | 6 | 2 |
| Penstemon attenuatus | | | | 4 | |
| Phlox hoodii | 6 | 16 | | | |
| Taraxacum officinale | 2 | | | | |
| SHRUBS | | | | | |
| Artemisia tridentata | 240 | 170 | 208 | 116 | 74 |
| Mahonia ripens | | | | 16 | |
| Chrysothamnus nauseosus | | | | | |
| Chrysothamnus viscidiflorus | 12 | 10 | 26 | 48 | 22 |
| Purshia tridentata | 6 | 60 | 3 | | |
| Symphoricarpos oreophilus | | | 38 | 8 | 24 |
| TOTALS | 474 | 444 | 612 | 546 | 498 |

COMPOSITION FROM DRY WEIGHT FOR CANYON #2

| SPECIES | TRANSECT 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| GRASSES AND GRASSLIKES | | | | | |
| Agropyron smithii | 8 | 11 | 26 | 26 | 34 |
| Agropyron trachycaulum | 2 | | | | |
| Bromus marginatus | | | | 1 | 2 |
| Carex geyeri | 4 | | 5 | 1 | 4 |
| Elymus cinereus | | | 1 | 14 | 7 |
| Festuca idahoensis | 23 | 16 | 8 | 10 | 3 |
| Koeleria cristata | | 1 | | | |
| Melica bulbosa | | | | | 1 |
| Poa fendleriana | | 1 | 1 | 2 | 1 |
| Poa pratensis | 1 | | | | |
| Poa secunda | | 3 | | | |
| Stipa columbiana | | | 1 | | 2 |
| Trisetum spicatum | | | 1 | | |
| FORBS | | | | | |
| Achillea millefolium | | | | 1 | |
| Annual spp. | 1 | 4 | 2 | 3 | 4 |
| Antennaria corymbosa | | | | | |
| Arnica cordifolia | | | | | 5 |
| Arabis spp. | | | | 1 | |
| Aster spp. | 2 | 1 | 1 | 1 | 2 |
| Balsamorhiza sagittata | | | 4 | 1 | 1 |
| Calochortus nuttallii | | | | | |
| Crepis acuminata | | | 1 | 1 | |
| Eriogonum umbellatum | 2 | 4 | 3 | 1 | 4 |
| Geranium fremontii | | | 1 | 1 | |
| Hackelia floribunda | | | | | 5 |
| Linum lewisii | | | | | |
| Lupinus spp. | 1 | 2 | | 1 | |
| Penstemon attenuatus | | | | 1 | |
| Phlox hoodii | 1 | 3 | | | |
| Taraxacum officinale | | | | | |
| SHRUBS | | | | | |
| Artemisia tridentata | 52 | 34 | 33 | 21 | 15 |
| Mahonia ripens | | | | 2 | |
| Chrysothamnus nauseosus | | | | | |
| Chrysothamnus viscidiflorus | 2 | 2 | 4 | 9 | 5 |
| Purshia tridentata | 1 | 13 | 1 | | |
| Symphoricarpos oreophilus | | | 5 | 1 | 5 |
| TOTALS | 100 | 100 | 100 | 100 | 100 |

DRY WEIGHT PRODUCTION IN POUNDS PER ACRE FOR CANYON #3

| SPECIES TRANSECT | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| GRASSES AND GRASSLIKES | | | | | | | | |
| *Agropyron spicatum inerme* | 136 | 170 | 92 | 304 | 310 | 222 | 244 | 120 |
| *Bromus marginatus* | 4 | | 10 | 26 | 16 | 18 | 2 | |
| *Carex geyeri* | 84 | 52 | 32 | 50 | 26 | 108 | 38 | 26 |
| *Elymus cinereus* | | | | | 102 | 36 | | |
| *Festuca idahoensis* | 16 | 14 | 4 | 18 | 28 | 44 | 48 | 70 |
| *Poa epilis* | 4 | | | | | | | |
| *Sitanion hystrix* | | | | | | 4 | | 8 |
| *Trisetum spicatum* | | | | | 4 | | | |
| FORBS | | | | | | | | |
| *Achillea millefolium* | | | | 4 | | | | |
| *Agastache urticifolia* | | | | | 4 | 24 | 2 | |
| *Annual* spp. | 20 | 14 | 24 | 24 | 12 | 18 | 4 | 6 |
| *Antennaria corymbosa* | | | | | 4 | 4 | | |
| *Arnica cordifolia* | | 4 | | 2 | | 4 | | |
| *Aster* spp. | 2 | 2 | 6 | 4 | | 14 | 4 | 4 |
| *Balsamorhiza sagittata* | 6 | | | 4 | 10 | 4 | 10 | |
| *Eriogonum umbellatum* | 18 | 8 | 4 | 12 | 9 | 4 | 12 | 38 |
| *Fragaria virginiana* | | 2 | 4 | | | | 4 | 10 |
| *Geranium fremontii* | 14 | 4 | 6 | 4 | 4 | | | |
| *Hackelia floribunda* | 2 | | | | | 6 | | |
| *Helianthella uniflora* | 34 | 2 | 12 | | | | | |
| *Lomatium dissectum* | | | | 4 | 6 | | | |
| *Lupinus* spp. | 16 | 26 | 8 | 14 | 34 | 2 | | 30 |
| *Osmorhiza occidentalis* | | | 10 | | 8 | 4 | | |
| *Penstemon attenuatus* | | | | | 10 | 2 | 10 | 30 |
| *Potentilla gracilis* | 6 | 2 | 4 | | 6 | 4 | | |
| *Taraxacum officinale* | | | | | 6 | 6 | | |
| SHRUBS | | | | | | | | |
| *Amelanchier alnifolia* | 4 | | | | | | | |
| *Artemisia tridentata* | 22 | 50 | 32 | 46 | 72 | 42 | 34 | 24 |
| *Ceanothus velutinus* | 4 | | 6 | | | | | |
| *Chrysothamnus nauseosus* | 16 | | | | | | | |
| *Chrysothamnus viscidiflorus* | | 2 | 2 | 10 | 16 | 6 | 28 | 78 |
| *Mahonia ripens* | | 6 | 12 | 16 | | 10 | 10 | 6 |
| *Prunus virginiana* | 4 | 4 | | 6 | | 4 | 6 | |
| *Ribes cereum* | 4 | 4 | | | | | | |
| *Symphoricarpos oreophilus* | 8 | 20 | 34 | 32 | 40 | 26 | 18 | 10 |
| TOTALS | 424 | 386 | 302 | 580 | 728 | 616 | 474 | 460 |

COMPOSITION FROM DRY WEIGHT FOR CANYON #3

| SPECIES TRANSECT | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| GRASSES AND GRASSLIKES | | | | | | | | |
| *Agropyron spicatum inerme* | 31 | 45 | 30 | 52 | 42 | 33 | 51 | 26 |
| *Bromus marginatus* | 1 | | 3 | 4 | 2 | 3 | | |
| *Carex geyeri* | 20 | 14 | 11 | 9 | 4 | 18 | 8 | 6 |
| *Elymus cinereus* | | | | | 14 | 6 | | |
| *Festuca idahoensis* | 4 | 4 | 1 | 3 | 4 | 7 | 10 | 15 |
| *Poa epilis* | 1 | | | | | | | |
| *Sitanion hystrix* | | | | | | 1 | | 2 |
| *Trisetum spicatum* | | | | | 1 | | | |
| FORBS | | | | | | | | |
| *Achillea millefolium* | | | | 2 | | | | |
| *Agastache urticifolia* | | | | | 1 | 4 | | |
| *Annual* spp. | 5 | 4 | 10 | 4 | 2 | 3 | 1 | 1 |
| *Antennaria corymbosa* | | | | | 1 | 1 | | |
| *Arnica cordifolia* | | 1 | | | | 1 | | |
| *Aster* spp. | | | 1 | 1 | | 2 | 1 | 1 |
| *Balsamorhiza sagittata* | 1 | | | 1 | 2 | 1 | 2 | |
| *Eriogonum umbellatum* | 4 | 2 | 1 | 2 | 1 | 1 | 3 | 8 |
| *Fragaria virginiana* | | | 1 | | | | 1 | 2 |
| *Geranium fremontii* | 3 | 1 | 1 | 1 | 1 | | | |
| *Hackelia floribunda* | | | | | | 1 | | |
| *Helianthella uniflora* | 9 | | 4 | | | | | |
| *Lomatium dissectum* | | | | 1 | 1 | | | |
| *Lupinus* spp. | 4 | 7 | 3 | 2 | 5 | | | 7 |
| *Osmorhiza occidentalis* | | | 3 | | 1 | 1 | | |
| *Penstemon attenuatus* | | | | | 2 | | 2 | 7 |
| *Potentilla gracilis* | 1 | | 1 | | 1 | 1 | | |
| *Taraxacum officinale* | | | | | 1 | 1 | | |
| SHRUBS | | | | | | | | |
| *Amelanchier alnifolia* | 1 | | | | | | | |
| *Artemisia tridentata* | 5 | 13 | 14 | 8 | 6 | 7 | 7 | 5 |
| *Ceanothus velutinus* | 1 | | 1 | | | | | |
| *Chrysothamnus nauseosus* | 4 | | | | | | | |
| *Chrysothamnus viscidiflorus* | | | | 2 | 2 | 1 | 6 | 17 |
| *Mahonia ripens* | | 1 | 4 | 3 | | 2 | 2 | 1 |
| *Prunus virginiana* | 1 | 1 | | 1 | | 1 | 2 | |
| *Ribes cereum* | 1 | 2 | | | | | | |
| *Symphoricarpos oreophilus* | 2 | 5 | 11 | 5 | 6 | 4 | 4 | 2 |
| TOTALS | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

# APPENDIX B

ANOVA of data on independent variable effects on utilization.

| Number | Degree of freedom | Sums of squares | Mean square | F ratio | Significance |
|---|---|---|---|---|---|
| A | 4 | 31310.4308 | 7827.6077 | 18.6651 | ** |
| B | 8 | 39510.9333 | 4938.8666 | 12.1241 | ** |
| C | 6 | 25565.3321 | 4260.8886 | 9.8757 | ** |

A Interaction between slope and utilization
B Interaction between distance from water along the contour and utilization
C Interaction between air-line distance from water and utilization
* Significant
** Highly significant

ANOVA of data on independent variable effects on utilization.

| Number | Degree of freedom | Sums of squares | Mean square | F ratio | Significance |
|---|---|---|---|---|---|
| D | 7 | 28526.5564 | 4075.2223 | 9.5482 | ** |
| E | 6 | 24332.4482 | 4055.4080 | 9.3504 | ** |
| F | 7 | 34167.9856 | 4881.1408 | 11.7213 | ** |

D Interaction of distance from salt and utilization
E Interaction of soil disturbance and utilization
F Interaction of cow dropping per acre and utilization
* Significant
** Highly significant

# APPENDIX C

ANOVA of data on effect of forage on utilization.

| Number | Degree of freedom | Sums of squares | Mean square | F ratio | Significance |
|---|---|---|---|---|---|
| A | 3 | 13727.5898 | 4575.8633 | 10.1530 | ** |

A Interaction between forage and utilization
* Significant
** Highly significant