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# Impact of Grazing on Foothill Vegetation

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**FINAL REPORT**

# IMPACT OF GRAZING ON FOOTHILL VEGETATION


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## ABSTRACT

Defoliation of individual plants by sheep grazing a shrub-steppe community in the foothill ranges of northern Utah was examined during a spring grazing. Five sites (each approx. 120 $m^2$) within the paddock were monitored and populations of one or more species (*Aster chilensis*, *Wyethia amplexicaulis*, *Lupinus sericeus*, *Poa secunda* and *Koeleria cristata*) within these sites were examined daily for defoliation over a 25-day period. Sheep commenced grazing each site at different times. Once grazing commenced each site was visited daily. The frequency of defoliating *A. chilensis* shoots was highest for two or three days after grazing commenced. As forage availability declined the frequency and extent of defoliating plants of *W. amplexicaulis* (a low palatability species) increased at one site but for palatable species there was no evidence that extent of defoliation changed with declining herbage availability. Proximity of individual plants to shrubs did not appear to affect the pattern of utilization.

## INTRODUCTION

There have been many studies in which the diets of animals have been estimated either by direct observation of feeding animals or examination of the ingesta or feces. These have provided much valuable information about what plant species animals selectively eat in relation to the species on offer. However, there is inadequate quantitative information on the influence of animal grazing on individual plants that comprise the plant community. Recently Klemmedson et al. (1978), in reviewing research needs on western rangelands of the U.S.A., concluded that the highest priority is the study of the dynamics of individual plants and plant communities in relation to grazing and other stresses.

Information on the frequency and extent of defoliation is required to explain how composition and productivity of particular plant communities are altered by grazing or browsing animals. Plant physiologists have shown that shoot removal by clipping, at different frequencies and extents, influences vigor and survival of range plants. Implicit in these experiments is that clipping reasonably simulates grazing. However, data on the way free-ranging animals defoliate plants are insufficient to know whether clipping satisfactorily simulates grazing.

The frequency at which tillers of grasses are defoliated by sheep has been examined by Hodgson (1966), Hodgson and Ollerenshaw (1969) and Morris (1969). In these studies, the pastures were grass monocultures and it was found that the frequency at which tillers were grazed increased with increasing stocking density. To my knowledge there are no comparable studies reported for rangeland communities, although studies are currently in progress in southern Africa (Barnes 1976).

The aim of the study reported in this paper was to define the frequency and extent of defoliation of herbaceous plants by sheep grazing a shrub-steppe community in the foothill ranges of northern Utah. Individual plants and parts of plants were monitored during the grazing period to determine the rate of defoliation.

## STUDY METHODS

### Location

The study was conducted in a 2.43-ha paddock which was part of a large grazing trail at Hardware Ranch near Logan, Utah (Jensen et al. 1972). The paddock had an elevation of 1800-1900 m above sea level, and sloped away to the south. Soils of the area are of the Arid Flat and Yeates Hollow series (Doell 1966). Average annual precipitation is 406 mm and the frost-free period is usually from mid-June to mid-August.

Vegetation on the site and in the general area is of the sagebrush-grass type and is representative of the foothill ranges of much of Utah and southern Idaho. The dominant shrub in the paddock was Big Sagebrush (*Artemisia tridentata* ssp. *typica*), and Bitterbrush (*Purshia tridentata*) was abundant. There were limited areas dominated by Low Sagebrush (*Artemisia tridentata* ssp. *arbuscula*; Fig. 1). The dominant herbaceous species was Aster (*Aster chilensis* ssp. *ascendens*), and Mule Ears (*Wyethia amplexicaulis*) was abundant in some areas. Lupine (*Lupinus sericeus*) and Yarrow (*Achillea millefolium*) were common. The most common grasses were Sandberg Bluegrass (*Poa secunda*) and Junegrass (*Koeleria cristata*).

### Study Sites

Before sheep entered, the paddock was surveyed to define the distribution of the major shrubs, and five study sites were selected (Fig. 1). Four of the sites (A, C, D and E) measured 11 x 11 m and site B, which followed the stream bed was 55 x 2 m (average) wide.

The canopy cover of the shrub species in each site was determined using line transects positioned about 1 m apart. From the proportion of the line intercepted by shrubs, the percentage cover was estimated. To estimate the density of Mule Ears plants, the numbers of plants within stratified belt transects 0.3 m wide and up to 11 m long were counted.

The structure and composition of the herbaceous layer in sites A, B, C and D (including Low Sagebrush in A) was described by estimating the mean Leaf Area Index (LAI) for each species using the inclined point quadrat method (Warren Wilson 1960). A pin angle of 32.5° was used as the majority of the species had an erectophile habit (Warren Wilson 1959). There were 12 quadrats for each site and the position of each was determined by restricted randomization. In sites C and D the quadrat was placed in the open spaces between bushes. The position of each quadrat was marked with nails pushed into the ground. After the grazing period, the LAI of each quadrat was again determined.

### Grazing Period

On May 27, 19 sheep (12 ewes and 7 lambs) were placed in the paddock and 6 days later, June 6, another 27 (14 ewes and 13 lambs) were added. All were removed from the paddock on June 21. On the basis of a mature ewe plus lamb equaling 0.2 animal units, the paddock carried 0.5 AUM's per acre, or provided 77 sheep days per acre.

### Measurements on Individual Plants

Within each site 50 small pegs were pushed into the ground to form a grid of regularly spaced points. The stakes protruded above the soil surface, and it is assumed that sheep were neither attracted nor repelled by the presence of the pegs. Before sheep entered the paddock, individual plants of one or more species that were closest to the marker pegs were selected for repeated observation. The unit of plant selected differed according to species. For grasses the unit was the tiller, for Aster a shoot arising from a rhizome, and for Mule Ears and Lupine the whole plant. Since the plant unit selected was on the basis of closeness to each peg, it is assumed that the plants (or their units) marked represented a true subsample of the population of each species within each site.

To facilitate re-examination of plant units, a nail (head painted white) was pushed into the soil close to each unit.

Aster shoots were marked in sites A, B, C and D, Mule Ears plants in sites A and B, Lupine plants in Site E and grass tillers in site A. The grass tillers marked in this site were a mixture of two species that were initially difficult to distinguish (*Poa secunda* and *Koeleria cristata*).

Each day during the grazing period these marked plant units were individually examined. Care was taken to ensure that plants were examined only when the sheep were camping or feeding at a distance from a particular site. It was considered that sheep movements were not significantly affected by the daily examination of plants because of the cover offered by the shrubs and the relatively steep terrain.

Plant units were examined to see if they had been grazed during the preceding 24 hours. Examination of plants took place daily between 0930 and 1500 and the 24-hr period began and ended at 1200. The tips of all leaves of each plant unit were marked by covering a small area with white nail polish. When a leaf was partially or completely grazed, the grazed edge was re-marked. By this means, assessment of whether a plant had been grazed over the preceding 24 hr and the number of leaves grazed could be made from these measurements. The number of days between grazing of individual plants (termed the grazing interval) was calculated. The marking of leaves is unlikely to have influenced the choice made by the sheep as they are known to be color blind (Tribe and Gordon 1949).

The lengths of individual leaves that comprised each plant unit were measured at the start, during the grazing period

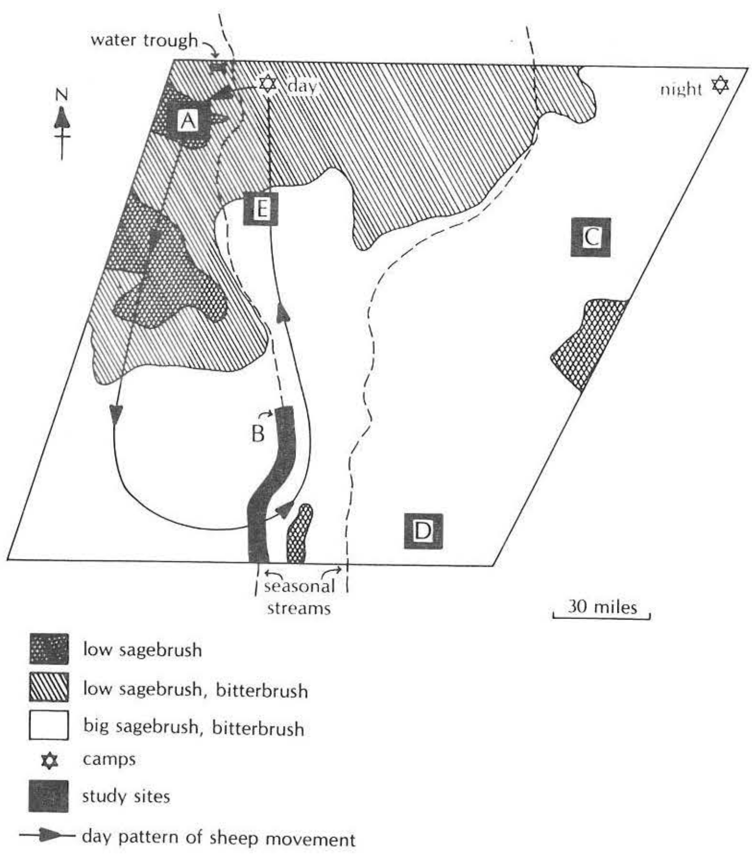


**Figure 1.** Layout of paddock showing distribution of vegetation types, study sites and pattern of sheep movement.

and after each defoliation. For the grasses, Aster and Mule Ears, a relationship between the total lengths and areas of those leaves on a shoot, tiller or plant was established by measuring the lengths and areas of leaves taken at random. From the lengths of leaves, the leaf area removed at each grazing was estimated.

Daily observations were made of the Bitterbrush to determine when the sheep started eating this shrub species.

### Animal Observations

During the hours each day when the paddock was visited to take the plant measurements, the position and behavior (resting, feeding or walking) of sheep were recorded at regular intervals.

## RESULTS

### Site Characteristics

Site A was dominated by Low Sagebrush and was the first area grazed by sheep as they left the day camp (Fig. 1).

Site B was the creek bed. For the first 10 days water flowed over some of this area and the soil remained moist for the duration of the grazing period. The amount of herbage and the diversity of species was the highest of all the sites (Table 1). During the day, sheep frequently grazed the creek bed on their return to the day camp.

Site C was typical of much of the paddock and contained a moderate cover of Big Sagebrush and Bitterbrush. The density of Mule Ears was also high on the site. No sheep were ever observed on this site. Since it was grazed, sheep must have visited the site during the late afternoon or early morning while moving to or from the night camp.

Site D was on a steep slope having a heavy cover of Big Sagebrush and Bitterbrush. It was the farthest site from either camp and sheep were seen grazing the site only on one occasion.

Site E was similar to sites C and D except it contained a significant number of Lupine plants, which were not present in any of the other sites.

### Grazing Pressure on Each Site

It was not possible to maintain continuous observation of the number of sheep, their feeding activities and duration in each site, but a relative index of daily grazing pressure was obtained from the proportion of plants grazed each 24-hr period. Although these data are species specific, the grazing pattern for all palatable plants is probably similar to that of Aster.

The grazing patterns for each site (Fig. 2) suggest that the sheep first utilized areas close to their day camp (sites A and B) and then grazed areas that were more inaccessible and with a heavier shrub cover (sites C and D). For all sites, but especially for C and D there were two or three days initially when grazing pressure was high (up to 30% of the shoots being grazed).

**Table 1.** Some characteristics of the study sites

| | Site A | B | C | D | E |
|---|---|---|---|---|---|
| Cover of shrubs (% of ground area) | 37 | 0 | 30 | 44 | 37 |
| Density (plants/m$^2$) of *Wyethia amplexicaulis* | 4.4 | 8.3 | 9.5 | 0 | 0.1 |
| Number of herbaceous species | 16 | 19 | 10 | 8 | N.A. |

Generally, after the sheep commenced grazing a site, it was visited at least once a day, even though the availability of herbaceous plant material became low after the initial heavy utilization.

Mule Ears plants were not eaten until Day 7 in site A and Day 11 in site B, and then only an occasional plant until forage availability in the paddock dropped to a low level. During the last six days of the grazing period, the proportion of the population of plants in site B that were grazed steadily increased to 46% on Day 26.

Lupine plants in site E were only grazed towards the end of the period; there was no indication that the grazing pressure on these plants increased with decreasing forage availability.

The grass plants on site A were utilized throughout the period, the highest grazing pressure being exerted early in the period and progressively decreasing as availability of forage from grass plants decreased.

Grazing of Bitterbrush commenced on about Day 15 and steadily intensified over the remaining period of grazing.

### Grazing Interval

The rate at which individual shoots were grazed as expressed by grazing interval varied from day to day (Fig. 2), the lowest grazing interval being 2.2 days for plants of Mule Ears in site B on the final day of the experiment. Means for the period that plants of a particular species were grazed differed between sites and between different species on a site. The mean grazing interval for Aster for sites A, B, C and D is 12.4 days.

### Influence of Shrubs on Utilization of Individual Plants

Regression analysis was used in seeking a relationship between proximity of individual shoots of Aster and grasses to adjacent shrubs and time of first grazing. For no site was there any statistically significant trend over time, indicating that all plants of these species were equally available to grazing sheep. The marked plants included those under as well as between bushes.

The only effect of bushes on utilization of a plant species was observed in site C, where on about Day 18 of the grazing period all Mule Ears plants under Bitterbrush shrub canopies were eaten partly (17 %) or completely (83 %) while plants in open spaces were largely ignored (5 % completely eaten, 57 % partially eaten and 38 % not grazed). The reason for the greater acceptability of plants under Bitterbrush is not known, but at the time it was thought that the shrubs protected those plants growing under them from the damage of a heavy frost that had occurred several days earlier.

### Frequency of Grazing Individual Plants

Overall, plants of the species examined were grazed an average of once or twice (Fig. 3). The Mule Ears plants, being larger, were grazed up to eight times on site B and only four times on site A. Shoots of a few Aster plants were grazed up to five times.

A greater proportion of Aster shoots were grazed twice on sites A and B than on sites C and D, an expected outcome of the greater grazing pressure on these first two sites.

### Amount Grazed from Individual Plants

The mean leaf area of Aster shoots was 7 $cm^2$ at the start of the experiment; there were no statistically significant differences between sites in the initial mean leaf area of the shoots selected. The mean amount of leaf area removed when shoots were first grazed was 5.3 $cm^2$ (75 % of the initial leaf area). For the grasses in site A, an average of 67 % of the leaf area of tillers was removed when first grazed (1.3 $cm^2$/tiller). The amount grazed at any one time from each Aster shoot or grass tiller was not significantly different between sites or over time.

In contrast, the less palatable Mule Ears plants in sites A and B were infrequently and lightly grazed initially, but as herbage availability decreased towards the end of the grazing period, the mean amount grazed from plants each day steadily increased from 100 to over 300 $cm^2$/day at site B (Fig. 4). No significant change in grazing pressure occurred for the plants in site A, however, suggesting that they were less attractive as forage than plants in site B.

The change in the leaf area of the populations of the species during the grazing period is shown in Figure 5. Differences in the rate and direction of change reflect the time when grazing commenced at each site and the subsequent grazing pressure. Note should be taken of the doubling in the leaf area of the Mule Ears plants before the sheep began grazing them.

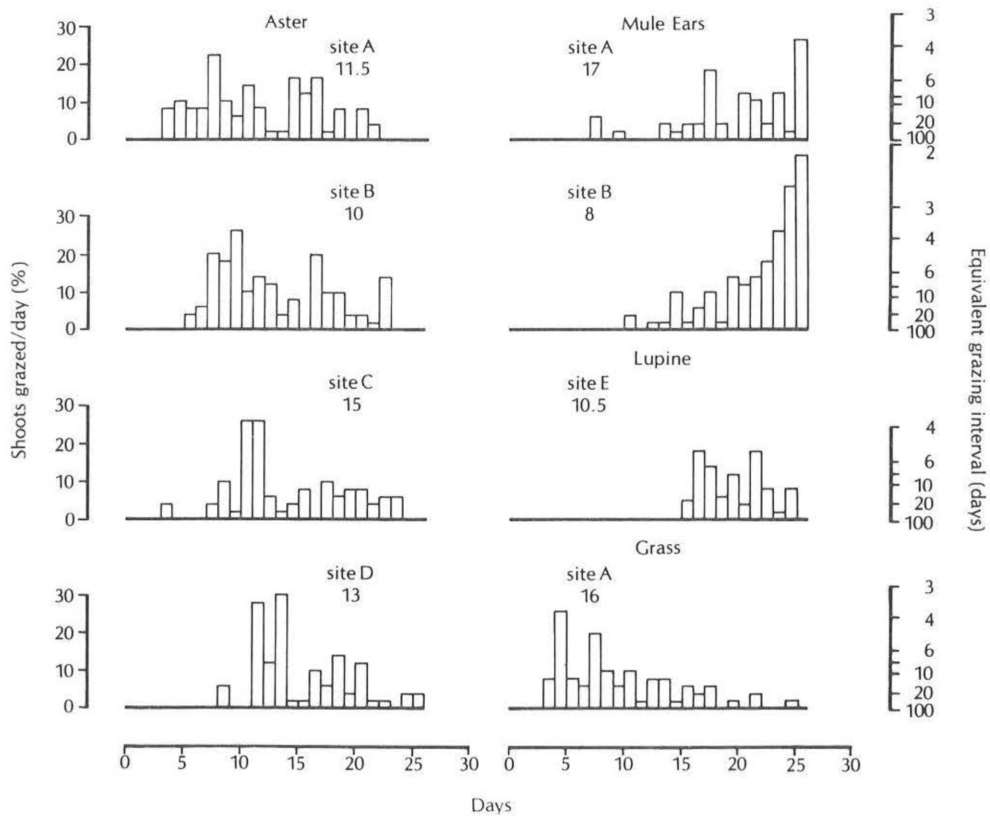


**Figure 2.** The percentage of the marked shoots of four species grazed at each site each day. Equivalent grazing intervals are shown on the vertical right axis. Mean grazing intervals for the period are presented under the name of each site.

### Amount Grazed from Sites

The measurement of the LAI before and immediately after grazing indicates the amount of herbaceous foliage removed from each site by the sheep (Table 2). Overall, the reduction was about 55%. This is less than the percentage of true utilization, as the method does not account for growth of plants before they were grazed. Compared with the amounts grazed from the marked plants (Fig. 5), the true utilization is probably 15% higher, about 70%. There are differences between sites in the percent utilization of the forbs and grasses present, but this is expected, as the grazing pressure differed among sites.

## DISCUSSION

This study is an attempt to describe the pattern of utilization of individual plants by sheep, in terms of the frequency and extent of defoliation. The method used led to a good description of how the most abundant herbaceous species were utilized over time. However, in discussing the implications of this study it should be recognized that: 1) the grazing situation was somewhat artificial in the sense that a small mob of sheep was confined in a small paddock and 2) only some of the plant species forming the sheep's diet were monitored.

The frequency at which shoots of the palatable *A. chilensis* were grazed fluctuated over time and differed between sites (Fig. 2). Following the commencement of grazing an area, a high proportion (25-30%) of the shoot population was grazed for several days, and then the proportion declined over time. The initial high consumption of shoots is due to an increase in the number of sheep grazing the particular area and/or an increase in the length of time each sheep spent grazing the area. The differences between sites in the starting of grazing is significant and can be attributed to distance of sites from the water trough and camps, and possibly differences in shrub cover. Presumably spatial heterogeneity in grazing patterns will increase as paddock size increases (holding

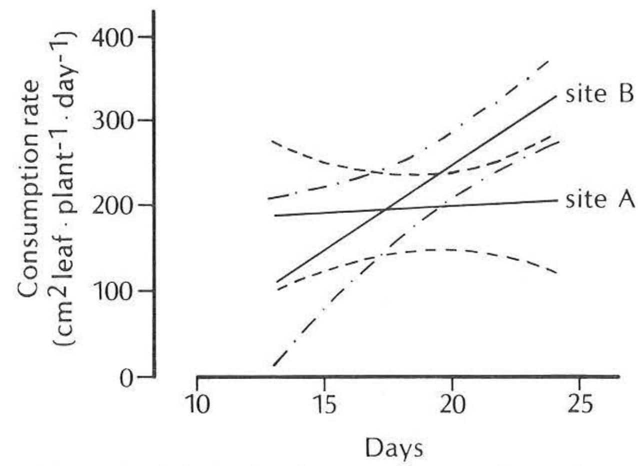


**Figure 4.** Relationship between consumption rate and days from the start of grazing for *Wyethia amplexicaulis* plants at two sites. The lines were derived by regression analysis and the dotted curves are the 95% confidence belts.

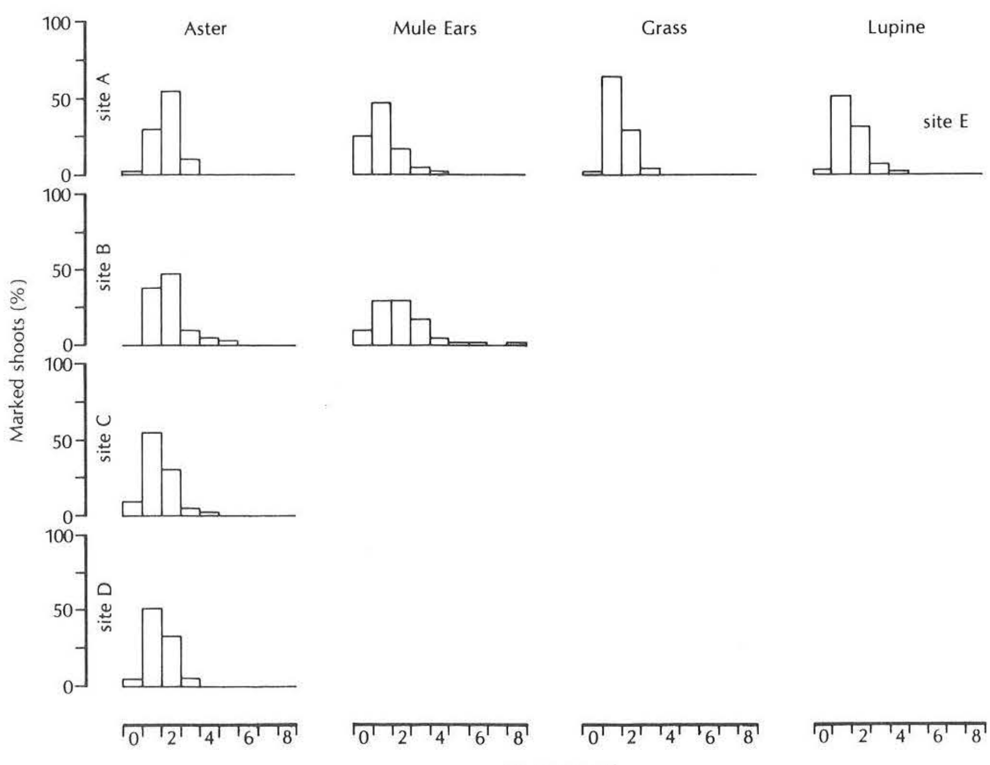


**Figure 3.** The percentage of the marked shoots of four species at five sites that were grazed different numbers of times during the period.

stocking density constant), or if stocking density is decreased (holding paddock size constant). The latter situation is well-known in practice and has been used as an argument in favor of rotational rather than set stocking grazing systems (Smith and Owensby 1978).

Another factor influencing the grazing pattern of plants is the closeness of plants to shrubs, assuming that sheep orient themselves towards conspicuous objects such as shrubs so that plants close to shrubs are grazed before plants in open spaces (Islander 1975). Support for this phenomenon was an experiment in which cardboard boxes were placed in a grass pasture and sheep tended to graze towards and around the boxes. When the data from this present experiment were examined for effects of shrub closeness or utilization, there was no evidence that plants close to shrubs were grazed in preference to those at a distance from shrubs. All plants appeared to be equally available for grazing by the sheep. In site C, however, the extraordinary consumption of Mule Ears plants under the canopies of shrubs may support Islander's hypothesis, but there are other explanations for the phenomenon.

Theoretically, the frequency at which shoots of a forb or tillers of grass are grazed by free-roaming sheep will be determined by the stocking density and the density of shoots or tillers. If we express frequency in terms of the mean number of days between grazing of shoots or tillers (grazing

**Table 2.** Leaf Area Indices (LAI) of the herbaceous species before and after grazing and the percentage change in the LAI of the key species and forbs and grasses that resulted from grazing.

| | | Site | | | | |
|---|---|---|---|---|---|---|
| | | A | B | C | D | Mean |
| LAI | before | 0.55 | 1.33 | 1.43 | 0.89 | |
| | after | 0.22 | 0.75 | 0.52 | 0.37 | |
| % utilization | | | | | | |
| forbs + grasses | | 61 | 43 | 64 | 58 | 56 |
| forbs | | 66 | 34 | 68 | 52 | 55 |
| grasses | | 48 | 58 | 50 | 65 | 55 |

interval), then the relationship to stocking density (assuming shoot or tiller density remains similar) takes the form of a hyperbolic curve (Fig. 6). This is because the grazing interval will halve if the stocking density is doubled. The effect of higher or lower shoot or tiller densities would be displacement of the curve above or below the theoretical curve drawn in Figure 6.

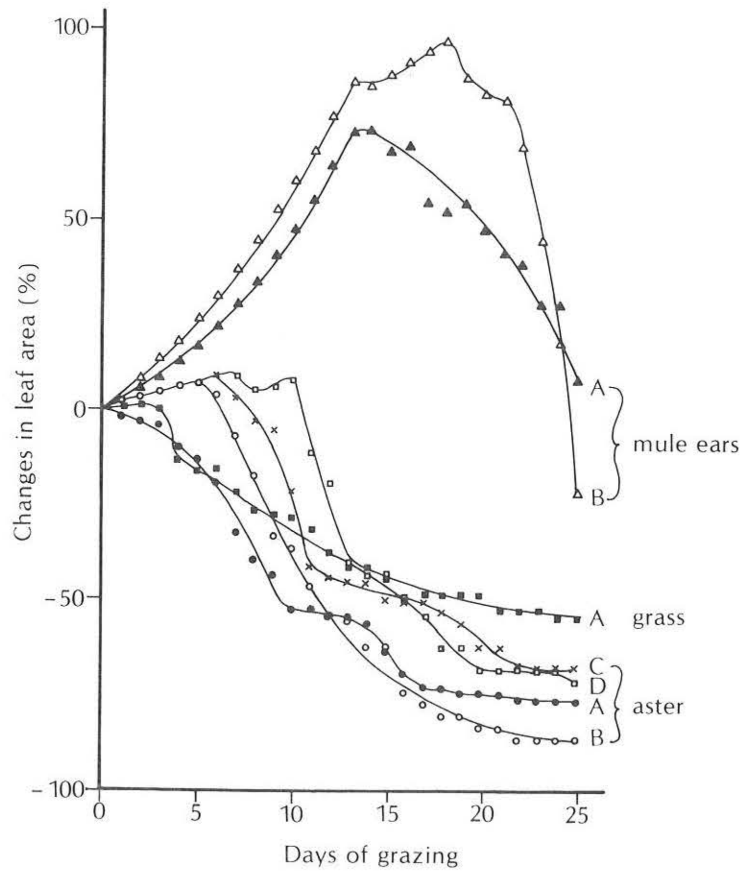


**Figure 5.** Percent changes in the leaf area of three species at four sites during the period of grazing.

Data from several sources (CSIRO 1965; Hodgson 1966; Hodgson and Ollerenshaw 1969; Morris 1969) are plotted in Figure 6 to indicate that the theoretical relationship is well-supported by data obtained from grazing experiments. All these experiments involved sheep grazing ryegrass pastures. The plant biomass on offer was high (170-618 $g/m_2$). This was also reflected in high LAI's (3-5.5 for Morris 1969). The mean grazing interval for shoots of *A. chilensis* was calculated to be 12.5 days, and when plotted against annual density was displaced to the left of the model curve. This should be expected, as the LAI was low (about 1.0) and the density of plant units would have been much lower than that of the ryegrass pastures of the English studies.

This theoretical relationship is expected to hold well where the stocking density is high and paddock size is small. However, where stocking density is low and paddock size is large, deviations from this relationship should be expected. Sheep, like all herbivores, are selective in their grazing, and if given the opportunity they favor certain areas and/or plant species. In rangelands where set stocking is the practice and stocking density is low (0.1-0.5 sheep/ha), e.g. Australia, the grazing interval for a given plant could vary over a year from 10 days (low biomass resulting from drought) to 360 days or longer (for an unpalatable grass species among abundant forage).

In an attempt to provide a theoretical framework for the way herbivores select their diets, Westoby (1974) hypothesized that the mix of nutrients eaten is optimized by a learning process. An implication of this theory is that as a food (especially a palatable species) becomes rare in a plant community, grazing pressure on it will increase. For the palatable species *A. chilensis* and the grasses, there was no evidence that as forage availability declined the amount removed from shoots or tillers increased. However, for *A. chilensis* this may be because of the short nature of the shoots and the physical impossibility of the sheep consuming more from each shoot. For the less palatable plant *W. amplexicaulis*, the grazing pressure did steadily increase during the final five days of the grazing period; the amount of leaf area removed from the plants increased over time (Figs. 4 and 5). This was more pronounced for the plants in site B than in site A. However, the increasing utilization of *W. amplexicaulis* can be satisfactorily explained in terms of low availability of other forage rather than resorting to a diet selection theory.

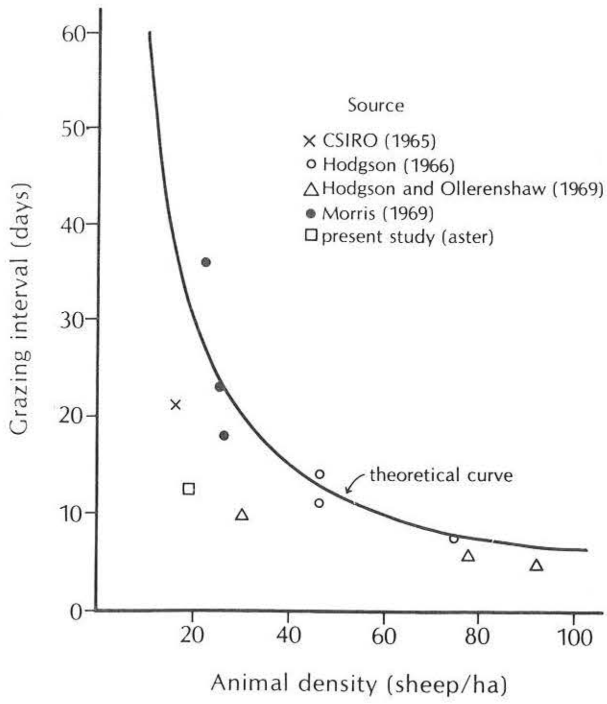


**Figure 6.** Theoretical relationship between grazing interval and animal density (curve) and actual points derived from other published work.

The large variation in palatability of *W. amplexicaulis* plants within the paddock is difficult to explain. It would seem that the differences between habitats in such things as soil moisture content and climate modification due to the presence of shrubs induce substantial changes in the palatability of the plants. Edaphic and climatic differences may affect palatability by altering the rate of phenological development.

The pattern of utilization defined for these species has several important implications for future studies on the effect of grazing stress on the population dynamics of individual plant species in communities. First, in multi-specific communities, populations of a plant species should be studied individually, especially where the species vary in palatability. Clearly it would be inappropriate to define the grazing pressure on plants in the community in terms of "the actual animal-to-forage ratio at a specific time" (Kothmann 1974). Had the sheep been removed five days earlier the grazing pressure on the *A. chilensis* and *W. amplexicaulis* populations would have been high and very low, respectively (Fig. 5) although the overall description for the biomass of herbaceous plants would be that of moderate to high grazing pressure. Secondly, it would be difficult to simulate the pattern of defoliation described in this study by cutting off leaves. Never was a plant completely defoliated in one day. In view of the difficulty in simulating grazing patterns, it would seem appropriate in future studies to examine the physiological stress imposed by grazing in natural communities that are subject to grazing, rather than to simulate grazing by cutting leaves off plants growing in artificial environments.

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## LITERATURE CITED

BARNES, D. L. 1976. A review of plant based methods of estimating food consumption, percentage utilization, species preferences and feeding patterns of grazing and browsing animals. Proc. Grassland Soc. South Africa 11:65-71.

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION. 1965. New light on the complex relationships between pastures and animal production. Pages 74-75 *in* Rep. CSIRO 1965-65, Melbourne.

DOELL, D. D. 1966. Effects of summer cattle grazing on big-game winter range in northern Utah. M.S. Thesis. Michigan State Univ. 55 pp.

HODGSON, J. 1966. The frequency of defoliation of individual tillers in a set stocked sward. J. Brit. Grassland Soc. 21:258-263.

HODGSON, J., and J. H. OLLERENSHAW. 1969. The frequency and severity of defoliation of individual tillers in set-stocked swards. J. Brit. Grassland Soc. 24:226-234.

ISLANDER, F. D. 1975. Factors affecting feeding habits of sheep grazing foothill ranges of northern Utah. Ph.D. Diss., Utah State Univ. 64 pp.

JENSEN, C. H., A. D. SMITH, and G. W. SCOTTER. 1972. Guidelines for grazing sheep on rangelands used by big game in winter. J. Range Mgmt. 25:346-352.

KLEMMEDSON, J. O., R. D. PIEPER, D. D. DURYER, W. F. MUEGGLER, and M. J. TRLICA. 1978. Research needs on western rangelands. J. Range Mgmt. 31:4-8.

KOTHMANN, N. M. 1974. A glossary of terms used in range management. Soc. Range Mgmt. 36 pp.

MORRIS, R. M. 1969. The pattern of grazing in continuously grazed swards. J. Brit. Grassld. Soc. 24:65-70.

SMITH, E. S., and C. E. OWENSBY. 1978. Intensive early stocking and season long stocking of Kansas Flint Hills Range. J. Range Mgmt. 31:14-17.

TRIBE, D. E., and J. G. GORDON. 1949. The importance of color vision to the grazing sheep. J. Agric. Sci., Cambridge 39:313-314.

WARREN WILSON, J. 1959. Analysis of the spatial distribution of foliage by two-dimensional point quadrats. New Phyt. 58:92-99.

WARREN WILSON, J. 1960. Inclined point quadrats. New Phyt. 59:1-8.

WESTOBY, M. 1974. An analysis of diet selection by large generalist herbivores. Amer. Nat. 108:290-304.