A study of the per cent of plants grazed method of utilization determination and its application
by James E Mattox

A THESIS Submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of Master of Science in Range Management
Montana State University

Abstract:
The data presented in this thesis include (1) variations and adaptability of the "per cent of plants grazed method" of utilization determination influenced by the grazing behavior of unherded sheep and (2) variations in" degree of utilization as influenced by variation in height-weight relationships .

The study area was located on the Shaw Ranch at White Sulphur Springs, Montana. The midcontinental climate was characterized by moderately low rainfall. The soils were gravelly or stony loams. The Palouse bunchgrass species and mixed prairie species were intermingled in the area.

A small band of unherded ewes and lambs was allowed to graze at will on the study area. They spread out widely in small groups and varied their choice of bed grounds. Factors influencing grazing habits included the feeding of hay, lambing camp locations, elevation, water barriers, exposure, slope, vegetation roughs, and plant species preferences,.

The vegetation and degree of utilization were systematically sampled and mapped. A composite plant for each species, representing all plants of this species in the study area, was developed and used as a basis for the development of a height-weight chart. This chart was used to determine percentage utilization from stubble height measurements. This height-weight chart was also used to develop graphs depicting the relationship of stubble height to per cent utilization.

Utilization values determined by use of the author' s height-weight table were compared to utilization values, for the same stubble heights, as taken from two different adaptations of Lommasson's utilization gauge. These paired values were statistically compared. The author's height-weight table for utilization determination appeared to be equally as accurate as the Lommasson utilization gauge for the areas studied.

The over-all utilization on the study area was 31.39 per cent, based upon the author'S height-weight table values for the measured stubble heights. A total of 79.5 animal unit months of grazing use occurred on the area during the study period. The area was stocked at the rate of 4.6 acres per animal unit month. The kentucky blue grass-timothy type was the most heavily utilized of the vegetation types. Sandberg bluegrass was the most heavily utilized of the plant species.

Graphs for the "per cent of plants grazed method" of utilization determination were prepared. The influence of the method of data summation was reflected in these graphs. Per cent of plants grazed graphs were prepared from data collected on the Shaw Ranch study area and from previously collected computed data for the Chadbourne Lease north of Livingston, Montana." The resulting graphs were compared statistically and were found to be significantly different between areas in nearly all cases.

The possibility of using the per cent of plants grazed graphs developed on the Shaw Ranch study area on another area of similar vegetation, for which they were not specifically prepared, was tested. This application of the method gave poor results with junegrass and sandberg bluegrass but good results

with some of the other plant species.

A STUDY OF THE PER CENT OF PLANTS GRAZED METHOD OF UTILIZATION DETERMINATION AND ITS APPLICATION.

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Approved:

Fred S. Willson
Head, Major Department

Chairman, Examining Committee

Dean, Graduate Division

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ABSTRACT

The data presented in this thesis include (1) variations and adaptability of the "per cent of plants grazed method" of utilization determination as influenced by the grazing behavior of unherded sheep and (2) variations in degree of utilization as influenced by variation in height-weight relationships.

The study area was located on the Shaw Ranch at White Sulphur Springs, Montana. The midcontinental climate was characterized by moderately low rainfall. The soils were gravelly or stony loams. The Palouse bunchgrass species and mixed prairie species were intermingled in the area.

A small band of unherded ewes and lambs was allowed to graze at will on the study area. They spread out widely in small groups and varied their choice of bed grounds. Factors influencing grazing habits included the feeding of hay, lambing camp locations, elevation, water barriers, exposure, slope, vegetation roughs, and plant species preferences.

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INTRODUCTION

The determination of degree of utilization on range forage plants is one of the most difficult problems encountered in managing grazing lands on a sustained yield basis. A number of methods for utilization measurement have been suggested and tried with varying degrees of success and satisfaction to the user, but no single method has been entirely satisfactory. In general, most of the accepted methods are too tedious and time consuming for the average rancher or administrator to apply. The large units of range ordinarily involved require a method which is rapid, easily used, easily understood, and reliable. Ordinarily, extreme accuracy is not as important as a well-distributed sample, yielding reliable results, on these large range units.

The "per cent ungrazed method" has been advanced as a possible solution to the problem of determining utilization on these large areas. A variation of this method uses the per cent of plants grazed. For purposes of simplification, this variation will be called the "per cent of plants grazed method" throughout this thesis. The per cent of plants grazed is determined by dividing the number of grazed plants by the total number of plants measured. The "per cent of plants grazed method" employs a graph of the relationship between the percentage of all the plants grazed and the total percentage of forage removed.

The primary objective of this study was to develop graphs, by the "per cent of plants grazed method," which would be applicable to measurement of utilization by sheep within the study area involved. The grazing behavior of unherded sheep was examined because of its influence on the

application and accuracy of the method. In addition, variation in the graphs, as influenced by various procedures of data summation, were to be studied. These graphs were also to be used to test the validity of using them on another area of similar vegetation for which they were not specifically prepared.

An objective of a secondary nature was involved. It was desired to test the reliability of the method of utilization determination used in this study. The reliability of these utilization values limits the value of the "per cent of plants grazed method" of utilization determination. Another procedure of utilization determination, the Lommasson gauge, involving the same basic concepts of height-weight relationships was used for this comparison. The same stubble height measurements were used.

This study was conducted with the Montana State College Experiment Station experimental sheep band on the Shaw Ranch at White Sulphur Springs, Montana. This ranch is leased by the Montana State College Experiment Station for sheep research. Data from a portion of the Chadbourne Ranch, just north of Livingston, Montana, is also included. This property was formerly leased by the Montana State College Experiment Station.

REVIEW OF LITERATURE

The use of utilization determinations as an aid in managing grazing lands is not new. Man has made use of this tool, with varying degrees of application and success, ever since grazing animals were first domesticated. These applications were of a general nature and were applied only as necessity required their use. Around the turn of the century, the conservation movement began to flourish, and the need for more complete information on utilization determinations became apparent. Progress in this field of research accelerated greatly in the early 1930's as several men began to study the problem and develop new methods of determining degree of utilization. The two general types of utilization determinations in use are the qualitative approach, by means of estimation, and the quantitative approach, by means of actual measurements.

QUALITATIVE METHODS

The qualitative approach was used by the old-time stockman as he judged how much of his feed was fully used and how much more grazing he could get from a particular unit of grazing land. These estimates were of an ocular nature and were greatly influenced by the man's judgment and experience. Various standards for proper use based upon these ocular estimates have been suggested. Sampson and Malmsten (1926) stated, "It is generally conceded that if from 10 to 25 per cent of the herbage of the more important palatable species remains in the fall, proper utilization has been affected." The U. S. Forest Service (1936) recommended that 25 per cent of the seed heads be allowed to reach maturity in addition to the specifications suggested by Sampson and Malmsten. This general reconnais-

sance method may involve any plant species or any portion of an area. The estimates may be in terms of percentage of height or volume removed or both, or they may be generalized in terms such as light, moderate, or heavy utilization. Presumably, estimates of the use will vary to a considerable extent in the application of this method. Smith (1944) found this to occur in estimating density.

Several variations of the general reconnaissance method have been devised and studied in recent years. The weight estimate method (Pechanec and Pickford, 1937) of determining range production substantiates the variation known as the ocular-estimate-by-plot method (Pechanec and Pickford, 1937a and Soil Conservation Service, 1944). In this method the weight estimates are limited to a plot of such limited area that all the plot is visible from one point. The average of several plots is the average utilization. Pechanec and Pickford (1937a) tested a refinement of the ocular-estimate-by-plot method, known as the ocular-estimate-by-average-of-plants method, and concluded that it was the most accurate of the methods tested. This method involves estimates of weight removal for each plant within the plot. The average of the estimates is taken as the utilization for the plot. Dasmann (1951), Hormay (1943), and others have applied the visual estimate method of utilization determination to browse. The percentage of use on individual shrubs is estimated by mental reconstruction of ungrazed appearance or of uncropped leader length.

A number of methods involving the use of general appearance have been used widely to determine the degree of utilization on generalized range areas. The primary forage plant method was described by Deming (1939)

and has been widely used by several federal agencies and by private ranchers. Specific information on factors which influence use, such as composition, abundance, vigor, reproduction mortality, poisonous plants, soil erosion, topography, water, rodents, fires, and season of use, are described. In addition, specific information about degree of utilization on each of the main forage plants is recorded. After a study of all the factors examined, the area is assigned to one of nine described classes of degree of use.

In the subalpine grassland ranges of Oregon and Washington (Pickford and Reid, 1942), a range was properly grazed when 50 per cent of the green fescue, the key plant, was utilized. This was determined by estimating the per cent of plants grazed to 1 inch or less, the per cent of plants grazed to less than 3 inches, and the per cent of plants ungrazed. For the same general vegetation types, Pickford and Reid (1942a) list guides to determine proper use by means of appearance and visual estimation of per cent used. The range-condition method of utilization survey, as suggested by Humphrey (1949), employs a flexible proper-use factor for each key species; the factor to be used depending on the range condition of the given forage type. The basis of this method is also appearance and estimation of per cent used.

A method of judging range utilization (Hormay and Fausett, 1942) of annual-type ranges in California was based on the appearance of the range as compared to standard photographs. Young (1945) further expanded this method for the U. S. Soil Conservation Service in California and developed several photographic guides for use in these vegetative types. A

guide to degrees of range use as applied in southwestern Texas (Osborn, 1947) also made use of this procedure of photographic comparison. Costello and Turner (1949) used photographs and charts as aids to determining current forage utilization of the short-grass range on the Central Great Plains. Indicators of degree of use are listed according to current forage production within range condition classes.

Lantow (1939) felt that utilization should be estimated separately for several species rather than on the over-all basis used in the primary forage plant and photographic methods. These values were then weighted by the percentage composition and totaled. Proper use was weighted and totaled in the same manner. The two sums were then divided to obtain the proper per cent utilization of the available forage.

QUANTITATIVE METHODS

The quantitative approach has been used by numerous researchers in their efforts to develop accurate, scientific methods of utilization determination. These methods involve measurements which vary from those which are very extensive to those which are very intensive.

One of the most recently developed methods for determining degree of forage utilization involves the counting of pellet groups and droppings and correlating them with estimated forage taken. Several researchers, among them McCain (1948), U. S. Forest Service Region 4 (Undated), and Parker (1953), have suggested and studied this method. The method is quantitative in regard to the counts but qualitative with respect to the estimated forage removal values. The conversion of animal population, determined by pellet counts, to forage consumed can be based only on

estimates of pounds of forage normally eaten by each class of animal during a 24 hour period.

Purely quantitative methods, such as weight measurement, have also been used as a means of determining percentage utilization. Much work has been done with the weight measurement system. Morgan and Beruldsen (1931) and Beruldsen and Morgan (1934) used a method in Australia which necessitates two clippings of the forage; 25 samples before and 35 samples after grazing. In the 1931 study the 25 before grazing samples were re-cut at the end of the grazing period to allow for regrowth during the grazing period. The 1934 study did not have a regrowth problem as the small pastures were grazed by sufficient numbers of sheep so that only one day elapsed between the clippings. The percentage of volume reduction in air-dry weight is taken as the percentage of forage utilized. If growth is appreciable between clippings, forage production and utilization may be determined by a method suggested by a Joint Committee of the American Society of Agronomy, American Dairy Science Association, and the American Society of Animal Production (1943). Two meter-square enclosure cages are placed at random in each pasture, and a third meter-square unprotected plot is located within 10 feet of the enclosures. The cages are moved after each clipping. Methods of a similar nature have been successfully used in the midwest by Fuelleman and Burlison (1939) and others. Klingman, et al. (1943) show statistically that the cages should be randomly located but the unprotected plot should be selected for its likeness to the two caged plots to give the best results. Nevens (1945) compared the relative values of 3 variations of cage management and clipping procedure

which have been used.

A modification of the weight method (Stapledon, et al., 1927 and Cassady, 1941) has been used to determine utilization on sheep range. This system is known as the "before and after grazing" method. The method involves collecting and weighing predetermined numbers of units (one twig, stem, leaf, other plant part, or the entire plant) just prior to and immediately following grazing. This method has given good results in range studies in Utah (Cook, C. Wayne, et al., 1948; Cook, Clyde J., et al., 1948; and Green, et al., 1951). It has also been used, by these same researchers, to determine the composition of a sheep's diet and the closely related dietary preferences of sheep. Morgan and Beruldsen (1931) and Beruldsen and Morgan (1934) separated their clippings by species in order to determine dietary preferences. Esplin, et al. (1937) attempted to determine the diet by multiplying species composition by the percentage of each species which has been consumed at the end of the grazing period.

The measurement of height has also been used to determine utilization. The height measurement method, as originally applied to the utilization of grass, was based on the premise that percentage utilization of grass is equal to the reduction in average leaf height as a result of grazing (Pechanec and Pickford, 1937a). If the volume were distributed equally throughout the height of the plant, this would be true. However, Lommasson and Jensen (1938, 1942, and 1943), Crafts (1938), Valentine (1946), and others found this assumption to be invalid.

A modification of this height measurement method has been applied to browse. This modification involves tagging twigs and measuring the cur-

rent year's growth before grazing and the same current year's growth after grazing. The differnece in length is converted to a percentage use figure for each tagged twig. All of these values are averaged for a total use figure. Nelson (1930), Julander (1937), members of the Inter-Agency Committee, Oregon-California Interstate Deer Range, (1948), and Dasmann (1951) are only a few of the research workers who have used this method.

A line transect method, involving a variation of the height measurement method, (Canfield, 1941; 1944; and 1950) has been used in southern Arizona and was found to be highly applicable as a research procedure. Stubble heights and diameters are measured along a 50- or 100-foot line transect and then arranged according to species and stubble-height classes. Total use is determined by weighting these values according to the proportion of each species present. This method has also been used by members of the Interstate Inter-Agency Committee (1948) in checking winter deer range forage utilization. A suggested method of measuring grazing use on bitterbrush (Hormay, 1943) involves a modification of the line transect in measuring the average diameter of the plant crown.

The conversion of stubble height measurements of grasses to weight removed was a very progressive step forward in the field of use determination. This was made possible by studies dealing with the height-weight distribution within individual grass plants. Lommasson and Jensen (1938) were the first to correlate height removal with weight removal in the principal grasses of the western range area. At almost the same time, Crafts (1938) reported upon a study which endeavored to tentatively determine the relationship between height and volume (by weight) in some of the

important southwestern range grasses. Further, this study endeavored to develop a possible method for measuring volume utilization directly while measuring the stubble heights on the range. Crafts (1938) stated that, "The curve of height against volume approaches a parabola in all cases, and there is always a great concentration of volume close to the ground."

Crafts (1938a) studied and reported upon the height-weight relationships in 11 important grasses in Arizona and New Mexico. Height-weight scales were developed for these grasses. Individual utilization guides using this method were written by Crafts (1938b, 1938c, and 1938d) and by Campbell and Crafts (1938) for 4 of the most important grass species of the Southwest.

In connection with these height-weight scales, definitions and concepts about proper use, utilization indicators, soils, range types, class of stock, topography, time to judge use, utilization panels, and the use of key species were presented in another publication (Crafts and Wall, 1938). Parker and Glendening (1942a) discuss these factors and give crop heights, proper use factors, and proper stubble heights for each plant species by condition class and slope.

Campbell (1942) and Lommasson and Jensen (1942 and 1943) gave instructions in constructing and using the tables and scales needed to determine utilization by the height-weight method. Lommasson and Jensen (1942 and 1943) tested their method and concluded that height alone could be used as the variable for the determination of the required number of plants to be used in constructing height-weight tables. They concluded that the height-weight principle, when properly used, was sound and more

accurate and uniform than the ocular estimate method for utilization determination. The ocular-estimate-by-plot method was compared with the height-weight method on green fescue range (Reid and Pickford, 1941). They reported varying results depending upon the uniformity of the stubble height and recommended the use of the ocular method because of its rapidity. Nevertheless, Pickford and Reid (1942) recognized the height-weight relationship in green fescue and plotted a height-weight distribution curve for the species. Heady (1950) studied the relationship between the growth form of five perennial grasses and yearly changes in climate, differences in habitats, composition of the species in the stand, and degree of herbage removal. He found the height-weight method useful when properly applied and evaluated.

Other researchers have suggested major modifications in the field procedure of the height-weight method. In a method employed to make it more applicable to mixed grass stands (Parker and Glendening, 1942) all the important species were used, rather than a few "key species," and the percentage composition was used to weight the respective utilization values. A modified application of the height-weight method, as used by Collins and Hurtt (1943) at the United States Range Livestock Experiment Station near Miles City, Montana, involved the use of marked links on a chain as plot centers, stubble-height measurements on "key species," and weighting by percentage of all grazed stems of the species involved. Valentine (1946) scaled the percentages of utilization on a card which is placed at the side of the plant so that the actual stubble height directly indicates the percentage of weight that has been removed. This greatly

reduces the amount of calculations needed. The method is also helpful in that the examiner is able to directly associate stubble height with utilization. Woolfolk (1949) used a modification of the height-weight method in the sheep research at the United States Range Livestock Experiment Station near Miles City, Montana. The method involves correction for yearly variation.

Not all workers have found the form factor principle to be an entirely sound approach to the determination of degree of utilization. The work at Miles City, Montana, indicated that the height-weight distribution and the ratio of culmed to culmless plants varied greatly from year to year (Collins and Hurtt, 1943 and Holscher and Woolfolk, 1953). Work in the Texas Panhandle (Caird, 1945) indicated that grasses growing on poor sites had only a very small proportion of the foliage above the first inch, while on good sites, much more of the foliage was distributed higher on the plant. Plants on poor sites were also much shorter in total height. Grazing to a certain percentage of the height may result in either under, proper, or over utilization depending upon the climate, site, and plant species because of the possible high variation in the large volume of herbage produced in the lowest part of the grass plant (Costello and Turner, 1944). Heady (1950) found that the percentage of weight of plants in 1-inch intervals of height did not vary consistently, either directly or indirectly, with average height, average weight, soil, temperature, precipitation, or species composition of the stand. He concluded, however, that the height-weight method is valid and useful provided its limitations and variations are considered. In 4 years of work in Utah, Clark (1945)

found that composite samples of all years and all zones would often show errors of 10 to 25 per cent when use was made of average height-weight tables. Each species exhibited its own variation in growth form as a result of differences in soil, exposure, shading, moisture conditions, and temperature. He concluded that the 10 species studied under the conditions described do not have a growth form that even approaches consistency and that the ocular-estimate-by-plot method is more accurate.

The stem-count method of utilization determination was introduced by Stoddart (1935). In this method he showed that percentage utilization was a direct function of the total number of stems grazed. This work was done with western wheatgrass (Agropyron smithii) and was deemed to be quite suitable. Pechanec (1936) tested this method with thickspike wheatgrass (Agropyron dasystachyum) and found it insufficiently accurate to merit its use. The stem-count method was further tested on bunchgrass, and it was found to be neither sufficiently accurate nor rapid to justify its use on this type of plant (Pechanec and Pickford, 1937a). Stem and twig counts were used in the Missouri Ozarks (Dalke, 1941) as a basis for determining degree of utilization of woody plants.

Canfield (1942 and 1944a) suggested a short-cut method for estimating utilization. This method is based upon the number of plants in a grass stand grazed to a stubble height of 2 inches or less, the number of plants grazed above a 2-inch stubble height, and the ungrazed balance. To use this system, the average per cent of plants grazed to a stubble height of 2 inches or less is estimated, by observation or systematic count, in terms of basal tuft area without regard for species, density, and composi-

tion. This value is referred to the chart for the balance of the data. Stoddart's method (1935) and this method were the original suggestions for the "per cent ungrazed method" as developed by Roach in 1950. Osborn (1947a) further suggested the "per cent ungrazed method" with his work on frequency tallies. In this method, the frequency of occurrence of different species and the percentages of each completely grazed, partially grazed, and ungrazed is systematically tallied in the field and then converted to per cent utilization.

The "per cent ungrazed method," as developed by Roach (1950), was a direct outgrowth of Canfield's findings (1942 and 1944) and later studies by S. Clark Martin (Roach, 1950). It is based on the grazing habits of cattle and on the relationship between the per cent of accessible perennial grass clumps grazed and the amount by weight of forage removed. Roach (1950) did not differentiate between species in his work. Hurd and Kissinger (1953) applied a variation of the method to idaho fescue (Festuca idahoensis) only, on the basis of the "key species" concept of grazing management. A modification of the method (Collins and Hurtt, 1943 and Holscher and Woolfolk, 1953) utilized the per cent of plants grazed multiplied by per cent of plant weight removed. Holscher and Woolfolk (1953) stated that "per cent of plants grazed was the most sensitive indicator of the degree to which a forage species had been grazed." They propose an adaption of their method involving only a tally of grazed and ungrazed plants. This tally is referred to a table listing the proper per cent of plants to be grazed, by topographic subtypes on both summer and winter ranges. Hunt, et al., (1954) determined utilization through a

combination of counting grazed and ungrazed plants and taking leaf height measurements.

Various authors have studied the problem of utilization determination and critically examined and compared the various methods which have been suggested. Cook and Stoddart (1953) outline and illustrate many of the problems encountered in this field of study. They state, "Adequacy of standard utilization measurement methods depends upon what information is desired and what application is to be made of the data." Heady (1949) and Humphrey (1949) have made comprehensive comparisons of the methods of utilization determination which have been used, as have Stoddart and Smith (1943), Sampson (1952), and Brown (1954). Stoddart (1952) discusses the various methods available and the problems involved. These methods are discussed from an agronomic angle by Ahlgren (1947). Dasmann (1948) has compared the various utilization methods in their application to deer range. Pickford and Reid (1948) studied the problem of utilization determination and pointed out the problem of non-uniformity of grazing and its effect on the determination of proper utilization. Campbell (1937) and Bailey (1945), in studying the riddle of utilization measurement, discuss the invalidity of using specific proper-use factors because of the variable influence of site and climate. According to Campbell (1943), the real problem is not the measurement of use but the interpretation of the measurements taken. According to Lantow (1938), "A method for utilization surveys is not solely a mathematical question, and I doubt whether it ever can be made so."

GRAZING HABITS

The grazing habits of livestock have been studied by men in various agronomic fields. James Anderson (1797), a Scottish farmer, developed a system of rotation pasture grazing based largely on his observations of cattle grazing habits. No practical development of a similar nature has been found in the annals of the western range in North America. Even the recorded, planned studies are of a rather recent date.

The grazing habits of cattle permitted development of the "per cent ungrazed method" of utilization determination (Roach, 1950). Cattle grazing freely with ample forage available will, as a general rule, graze a clump of grass only once and then move on to a fresh plant. They will not return to a grazed plant unless forage is short or until the grass has grown new succulent growth. Because of these grazing habits, the percentage of plants grazed and remaining ungrazed provide indices to the total grazing use of a plant species or a range area (Roach, 1950).

Environmental factors which can be influential in the behavior of a herd of bullocks were examined at Stratford-on-Avon. These factors were the natural conditions of climate, including seasonal changes in weather, and the system of grazing management (Tayler, 1953). Cold winds and driving rains cause cattle to stop grazing and drift with the wind in search of shelter (Hancock, 1950 and 1952). Cully (1937) studied the forage preferences of cattle and the factors that influenced grazing habits in southern Arizona. Weather conditions and exposure were closely related to the areas which were grazed heavily. Seasonal preferences for forage were noted. These fluctuations in forage preference were noted also by

Johnson (1953) and Harris (1954). Timber is an environmental factor influencing both grazing use and other environmental factors. Pickford and Reid (1948) studied the relative palatability of grasses for cattle on the timbered lands and grasslands of eastern Oregon. They found a lowered palatability of certain forage plants in the timbered areas. Holscher and Woolfolk (1953) and Peterson and Woolfolk (1955) discussed utilization variations due to the environmental factors of range subtypes, stocking rates, and distance from water. They found, as did Cully (1937), that cattle tended to heavily graze the bottom or stringer subtypes.

Temperatures in the temperate zones (Castle, et al., 1950; Hancock, 1950; and Waite, et al., (1951) had little effect on the time cattle spent grazing, but Hein (1935) reported that cattle grazing during the night lie down very soon after a cooling fog descends. Although grazing time was not influenced, loafing time was increased during warm days, either because of excess warmth or the prevalence of flies (Castle, et al., 1950 and Waite, et al., 1951). This increase in loafing time was due to the expenditure of less time on activities other than grazing.

Cattle prefer to graze in daylight, and a strong positive relationship exists between the length of day and the time cattle spend grazing in daylight (Hancock, 1953). Grazing steers were found to graze at night only at twilight or in moonlight (Hein, 1935). Hancock (1950) and Waite, et al., (1951) found that during the two months centered around the longest day of the year little or no grazing occurs in darkness, but with shortening days cows spend a greater part of their grazing time in darkness. This was contradicted by Peterson and Woolfolk (1955). Although

cattle prefer to graze during daylight, grazing follows a distinct pattern in that periods of intense eating alternate with periods of idling, rumination, and rest (Hancock, 1953 and Peterson and Woolfolk, 1955).

A statement by Johnstone-Wallace (1944) to the effect that the time spent grazing was almost constant irregardless of feed availability has not been substantiated by other researchers including Hancock (1953), Atkeson, et al., (1942), and Waite, et al., (1951). The relationship between rate of stocking and cattle habits tended toward more vigorous foraging by cows on heavily stocked range in the study conducted by Peterson and Woolfolk (1955). In New Zealand (Hancock, 1950) it was found that grazing times were definitely influenced by the quality of the forage. It has been suggested (Waite, et al., 1951) that cattle graze longer on green, succulent growth because it packs tighter in the rumen than coarse, dry plants, therefore requiring more grass to satisfy their appetites.

Studies dealing with the grazing behavior of cattle may be highly variable as to subject matter and application. A study may cover a single factor or many factors influencing grazing behavior. Hancock's (1950) study of inherent individuality of cattle as an influence in grazing behavior varies widely from the common type of study. A study such as length of grazing period and its influence on the amount of consumption (Waite, et al., 1951) is a more common and practical approach. Weaver and Tomanek (1951) used a common method by studying cattle behavior in Nebraska throughout 24-hour periods for a typical day, a hot day, and a cool day. Hubbard (1952), in reporting on cattle behavior on Canadian Plains ranges, was primarily interested in the practical aspects of forage

preference and amount eaten. Several other researchers have also studied grazing cattle behavior. In England there is an organization known as "The Association for the Study of Animal Behavior." Most of this work with behavior of cattle has been of a basic nature and only a limited amount of practical application has been accomplished. Tribe (1950) and Hancock (1950a) point out the need for care in the interpretation of livestock behavior studies.

Much less work has been done with the grazing behavior of sheep, as compared to cattle. Cory (1927) made comparisons of beef cattle, sheep, and goat activities and habits on the range. However, he did not study them during the hours of darkness after they once bedded down. He concentrated his effort on timing their various activities, although he did observe some forage preferences and grazing habits. Davies (1925) emphasized that stage of growth has an important influence on animal preference and that selectivity by sheep is in direct proportion to the amount of desirable herbage available. Doran (1943) timed the various activities of sheep and pointed out that the relative length of feeding time spent by grazing ewes on various forage plants was closely related to abundance of each plant species. He mentions that actual utilization is influenced by abundance and composition of the forage, habits of the sheep, season, stage of plant growth, climate, and management practices. Teigen (1949) noted the forage preferences of sheep while they grazed on mountain ranges.

Sheep preferences for certain portions of certain plant species was noted and studied in Utah (Cook, C. Wayne, et al., 1948; Cook, Clyde J.,

et al., 1948; and Green, et al., 1951). They noted that forage consumption was highly influenced by the amount of time spent grazing. Selectivity was influenced by season of use, plant association, intensity of grazing, external characteristics of the vegetation, and various site factors. Generally forbs, browse, and grasses were preferred in that order, and leaves were highly preferred to stems. They state that a relatively small number of species compose the bulk of the sheep's diet. Stapledon and Jones (1927) also found that more grass leaves than stems were eaten by sheep even though more stems were present.

Jardine (1910) observed the tendency for sheep to bed near any handy obstruction which happened to be close at hand whenever night overtook them rather than return to an established bedground. He indicated that mountain summer range grazed by sheep under fence supported from 25 to 50 per cent more sheep than were being grazed on the same acreage of similar range on which the sheep were herded by the methods generally practiced at that time. He states the pastured sheep made better gains in weight than the herded sheep. Improved methods of herding overcame much of this difference. This author also indicated that salting away from water in order to improve distribution on sheep range is not successful. Jardine and Anderson (1919) recognized a tendency for sheep to graze without regard to temperature as long as insects did not bother.

Relative grazing values and relative abundance of plant species, as related to sheep utilization, are discussed in connection with a sheep study at the United States Range Livestock Experiment Station near Miles City, Montana (Woolfolk, 1949). This study involved sheep that were grazed

in a sheep-tight pasture and not herded. They were located and counted twice daily. The grazing periods, resting periods, bedding periods, and temperature, insect and predator relationships were discussed. Low temperature and a cold wind would cause the sheep to drift with the wind. The fences served to obstruct natural sheep movement and served as a natural protection, resulting in severe overuse in localized areas along the fences. The author felt that herding is better than pasturing sheep in this range area.

DESCRIPTION OF THE AREA

GEOLOGY AND SOILS

The grassland area included in this study lies in the foothills of the Smith River Valley in Meagher County, Montana. The Smith River Valley occupies an intermountain basin between the Big Belt, Little Belt, and Castle Mountains. The basin is 40 miles long and 2 to 8 miles wide. Elevations range from 4,800 feet to 5,200 feet (Gieseker, et al., 1953). It is characterized by smooth gently sloping benchlands and ridges of sedimentary rock extending out from the mountains. These benchlands and ridges are separated by small intervening stream valleys. A few ridges and out-crops of igneous rocks occur locally in the basin. The benchland covering consists of limestone and argillite fragments, which occur over lake-bed sediments in most sections (Gieseker, et al., 1953). During the Wisconsin glaciation, ice accumulated in the Crazy and Castle Mountains to such an extent that it extended down to the mouth of the large canyons.

The Missouri River and its branches drain a large part of central Montana. One of its branches, Smith River, is the perennial stream that drains this intermountain basin between the Big Belt Mountains and the Little Belt and Castle Mountains. It rises in the Little Belt Mountains and wanders through wet bottom lands in the basin before turning northward to join the Missouri River in Cascade County. At Fort Logan it enters a canyon that becomes a gorge 800 to 1,000 feet deep in northern Meagher County. Its larger branches, such as the Tenderfoot River, flow through deep canyons and rock-walled gorges. Its South Fork heads in the southern part of the Castle Mountains and flows through the open valley before it

enters the main river.

The soils of central Montana differ greatly due to their physical, chemical, and biological properties as influenced by parent material and the prevailing climate. There are four general groupings of soils in the Smith River Basin. They are as follows: (1) farming soils, (2) farming-grazing soils, (3) grazing soils, and (4) miscellaneous soils and land types (Gieseker, et al., 1953). These groups reflect productive capacity to a great extent. This correlation is closely related to differences in climate and native vegetation.

The study area occurs on two of the benchlands extending out from the western side of the Castle Mountains, as shown in Figures 1 and 2. This area is cut lengthwise from east to west by a small intermittent stream known locally as Lone Willow Creek. One high bench of sedimentary rock (Figure 3) occurs in the northeast portion of the study area on the north side of Lone Willow Creek. There are four kinds of soils occurring on and adjacent to the study area. They are as follows: (1) Crago gravelly loam, a grazing soil; (2) Gilcrest loam and gravelly loam-undifferentiated, a grazing soil; (3) Alluvial soils-undifferentiated (dark-colored), a grazing and hayland soil, and (4) Hilger loam and stony loam-undifferentiated (some sharply rolling and broken), a farming-grazing soil (Gieseker, et al., 1953). These soils are all quite fertile and capable of supporting a good stand of grass with proper management practices.

CLIMATE

The climate of the Smith River Basin is midcontinental. Over most of this area the semiarid climate is characterized by moderately low rain-