Order Number 1341487

Seasonal variation in utilization estimates on sideoats grama plants

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The University of Arizona, 1990

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SEASONAL VARIATION IN UTILIZATION ESTIMATES
ON SIDEOATS GRAMA PLANTS

by

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A Thesis Submitted to the Faculty of the

SCHOOL OF RENEWABLE NATURAL RESOURCES

In Partial Fulfillment of the Requirements
For the Degree of

MASTER OF SCIENCE
WITH A MAJOR IN RANGE MANAGEMENT

In the Graduate College

THE UNIVERSITY OF ARIZONA

1 9 9 0

STATEMENT BY AUTHOR

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In Memory of

Dr. Roger C. Hungerford

who taught me that what really counted

was simply to do one's best.

ACKNOWLEDGMENTS

I extend my deepest appreciation and graditude to Dr. Phil Ogden. His continued assistance and guidance throughout the study has been invaluable. His knowledge, dedication and support to the range management program and its students is exemplary.

I appreciate Dr. Lamar Smith's and Larry Allen's constructive advice and critique of the manuscript, while serving on my advisory committee.

I would also like to extend my gratitude to the U.S. Forest Service for their continued support and assistance in ensuring the completion of this study. I would like to thank John Borrecco and Jim Shevock for their advice on the preparation of the thesis, and Jim Baldwin for his advice on the analysis of data.

Appreciation is also extended to the School of Renewable Natural Resources, University of Arizona; to Barbara Williams and the Department of Range Management, University of California at Berkeley for use of their laboratory facilities; and to Bill Kruse and other Santa Rita Experimental Range personnel for use of Pasture 302 and assistance with climatic information.

I would also like to extend my appreciation and gratitude to my husband for his encouragement and continued support of my range graduate program and field of study. His unselfishness allowed me to pursue a lifelong dream. I would also like to thank my family for their loving guidance, assistance and "words of wisdom" throughout my Master's program.

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ABSTRACT

The variabiity in utilization estimates using seasonal production data from clipped sideoats grama plants was studied in southeastern Arizona. Three intensities of clipping at four seasons were studied. Regrowth was also examined.

Current growth was at its highest in October and lowest in June, whereas, standing dead material was lowest in February and highest in June. By April 1986, 39% of peak current growth was already produced. Total peak standing crop occurred in October. The sum of current growth and regrowth from heavy clipping was greater than for plants clipped heavily only in October. The opposite was true for moderate and control clippings.

Actual utilization was calculated using peak current growth as a basis for calculating percentage utilization. Relative utilization estimates were based on standing crop at each season of clipping treatments. Generally, relative utilization estimates overestimated utilization when compared to actual utilization estimates based on current growth.

INTRODUCTION

In the field of range management, correct utilization of forage is an important item of concern, yet determining utilization is one of the most perplexing problems facing range managers today. Many methods have been developed for measuring percentage utilization of range plants; however, the accuracy and interpretation of the measurements obtained have varied widely (Heady, 1949; Stoddard, Smith, and Box, 1975). Because there are differences in the collection of production and utilization data, exact standards to measure the adequacy of utilization methods have been difficult to develop. This is dependent upon knowing what information is desired and the application to be made of the data. As a result, questions about the practical aspects of utilization measurements have been raised (National Academy of Sciences/National Research Council, 1962).

Good management and utilization of the forage is dependent upon an evaluation of the productivity of the forage resource. Forage can only be maintained in a vigorous, healthy state if it is used to such an extent where it can grow and reproduce. Forage production is affected by the amount and distribution of seasonal rainfall, temperature variations, wind, changes in plant vigor and condition, nutrient availability, fertilizers, rainfall during the previous season of growth and/or grazing intensity and frequency during previous seasons (Darrow, 1944). Livestock numbers are regulated to conform with forage production on an area. Adjustments to livestock numbers often are based on utilization measurements (forage grazed or herbage left).

Utilization of a range often is dependent upon such factors as topography, salt, distance to water, weather, herding, type of livestock, and the grazing system and season of use. In addition, pastures often include variable combinations of range sites and plant communities on which utilization is seldom uniform. As a result, it becomes critical to the range manager to be able to understand variability and the limits it sets and to be continually aware of this variability when making interpretations of data.

The initial problem in determining utilization is the measurement or estimation of the percentage or amount of the plant removed. Direct measurement of forage consumed is difficult and time consuming, so most methods rely on determination or estimation of forage remaining in relation to measured or estimated production (ie., caged plots or ungrazed plants). The second major problem is accurately measuring or estimating the annual production used as the base to calculate percentage utilization.

Caged plots and/or ungrazed plants are one method used as the reference to determine total production for calculating percent utilization. A major problem in arriving at accurate estimates of utilization is seasonal variability. By sampling standing crop at various seasons throughout the year, it is possible to evaluate and discuss seasonal variations in total standing crop and provide better estimates of production than for estimates derived using peak standing crop.

For the purpose of this study, total standing crop is the above-ground living and dead material attached to the plant at a point in time. This is composed of current growth and standing dead material. Current growth is defined as the above-ground green or light rust-brown material still attached to the plant and considered to have grown the previous spring or summer growing season. Standing dead is defined as the above-ground dark brown to gray-brown dead material still attached to the plant. Total standing crop should not be confused with peak standing crop. Peak standing crop is the point at which live and/or standing dead material reaches a maximum. In southern Arizona, late summer standing crop as determined by a single harvest is utilized as peak standing crop. Litter is not included.

The objective of my thesis is to evaluate and document variability in utilization estimates using seasonal production data from ungrazed plants. I will examine the "appropriate way" to determine annual production used as the base in calculating percentage utilization and what errors are involved when seasonal production estimates are used in calculating percentage utilization.

LITERATURE REVIEW

Utilization Defined

Throughout the history of range management, the term "utilization" has been differently interpreted and applied by range managers. To emphasize this point, four definitions of utilization are given below:

1. "The degree to which animals have consumed the useable forage production expressed in percentage" (Stoddart, Smith and Box, 1975, page 199).
2. "The percentage by weight of current year plant growth removed by grazing or browsing" (Bryant, et al., 1978, page 4.09).
3. "The degree to which animals have removed the current growth of herbage and is expressed in percentage of growth within reach of grazing animals" (Society of American Foresters, 1958, page 92).
4. "The proportion of current years forage production that is consumed or destroyed by grazing animals" (Glossary Revision Special Committee, Publications Committee, Society for Range Management, 1989, page 19).

These definitions are not consistent with one another. Stoddart, Smith, and Box's definition (1975) does not mention whether or not the percentage utilization measured refers only to the present year's growth or total growth utilized. This definition, as well as the definitions by Bryant, et al. (1978) and the Society for Range Management (1964) do not discuss whether forage measured is only that which grows within reach of grazing animals (available) or is a measure of all forage (available plus unavailable). Nor do these definitions state whether forage measured is only that which is useable by grazing animals or whether it is a measure of all forage whether useable or not. The definitions by Bryant, et al. (1978) and the Society of American Foresters (1958) do not mention whether utilization is a measure of forage consumed or destroyed by grazing animals, or is a measure of forage consumed by grazing animals and other animal species (i.e., insects, small mammals, etc.). The gaps observed in defining utilization have led to a wide range of discrepancies in its measurement.

In general, the Glossary Revision Special Committee, Publications Committee, Society for Range Management (1989) definition for utilization seems most appropriate to use. The definition provides for consistent application without the inclusion of a decision on what is available or useable forage. The definition provides for a utilization estimate which should best correlate with the physiological responses of plants to herbage removal.

General Problems in Measuring Current Production

Problems in deriving sound utilization measurements can be a result of gathering poor current production estimates. Generally, production measurements are taken at the end of the growing season and reflect annual production of available forage. In the Southwest, where two growing seasons occur, production measured at any one time never represents the true total production for the year. Underestimates of total production can be slight or range up to about 50% of the true value (Smith, no date). Additionally, a single measure of total peak production tends to underestimate total production because various forage species reach peak production at different times and loss of plant parts occur differently for each species throughout the year (Haile, 1981). Kelly, Van Dyne, and Harris (1974) found that a single measurement of total peak production underestimated total annual production due to death and shedding, as well as consumption.

If an area is being grazed when production is measured, problems with collecting production measurements may result if the plants being measured are not protected from grazing or the amount of forage consumed is not estimated and added to the production measured. Regrowth of plants after grazing can also cause errors in estimating production and/or utilization. So too can production measurements taken using plants which have not been oven or air dried before weighing. The moisture content of plants varies greatly depending on the plant part, season, time of day, and soil moisture content (Smith, no date). Finally, it should be mentioned that measuring production for one year will not likely give an average annual production for an area. Therefore, measurements of production need to be done repeatedly over several years or adjusted for growing conditions for data to be valid. Estimates of utilization seldom take into account the loss of forage caused by insects and other native herbivores. In many pastures being grazed at less than their carrying capacity, livestock are not as great a bulk as the total weight of insects and other wild animal life existing there (Brown, 1954). The failure to include use by these species in the loss of forage can lead to serious distortions in the analysis of utilization measurements.

The use of cages to measure production has been considered somewhat undesirable because of their effect on vegetation. Yields under cages have been found to be significantly greater than from unprotected areas (Cowlishaw, 1951). Cowlishaw attributed these results to the reductions of wind velocity and an increase in humidity inside the cages. Similar results were obtained by Heady in 1957 during the early part of the growing season. However, Heady discovered that when plants matured, differences in growth in and out of cages had disappeared. Daubenmier (1940) felt that the utmost attention should be directed toward minimizing the effect of the enclosures upon wind movement, insolation, and precipitation. His recommendation was to make large enclosures with the lowest and most open structures possible.

Differences in growth on protected and grazed areas can distort utilization. Cook and Stoddart (1953) found that the cage method yielded biased results because the growth rate of plants being grazed was different than that of protected plants. The greater period of time between caging and clipping, the larger this bias becomes. A Joint Committee of the American Society of Agronomy, American Dairy Science Association, and the American Society of Animal Production (1943) proposed a two-cage technique for use during the growing season to eliminate cage bias.

Utilization Methods

Numerous methods have been developed to measure utilization. Some are rapid and others may be more time consuming and detailed. Most methods rely on a reference of total production to determine utilization. The primary forage plant, height measurements when utilization is expressed as a percentage of height, and general photographic methods are exceptions. The methods developed to measure utilization include:

General Reconnaissance

Estimates are made of the percentages of total plant height or volume production removed by grazing (Pechanec and Pickford, 1937a). Comparisons are made between undisturbed growth and the grazed range. This method is fast, no plants are measured and few plots if any are used. "The accuracy of the estimates depends largely upon the experience and judgement of the range manager" (Heady,1949, page 54). Variations of the reconnaissance method have been made, the most useful being the weight estimate by plot for determining forage yield and calculating stocking rates (Pechanec and Pickford, 1937a; Sampson, 1952).

Ocular Estimate by Plot

This method is a refinement of the reconnaissance procedure and was developed by Pechanec and Pickford (1937a). It is an estimate of the percentage of herbage removed in terms of weight. It is a rapid and relatively easy method. "It differs from the general reconnaissance method in that each estimate is made on a plot of such limited area that the entire plot is visible from one point and percent utilization is the average of the estimates from a series of plots selected at random" (Pechanec and Pickford, 1937b, page 755). As with the general reconnaissance method, percent utilization of weight, height, or volume is estimated. Training is done by clipping small plots at various levels and then estimating percent removed.

Ocular Estimate by Average of Plants

This method evolved as a refinement by Pickford and Pechanec (1937a) of the ocular estimate by plot method. It is similar to the plot method except estimates are made on individual plants rather than plots. The percent removal of weight is estimated for each plant within the plot and an average of the estimates is used as percent utilization for the plot (Heady, 1949). Although more time is consumed using this method than for the ocular estimate by plot procedure, this method is still relatively rapid to use.

Primary Forage Plant

This method, discussed by Deming (1939), describes the general appearance of the range under each of nine degrees of use. The range is classified into utilization zones by describing the appearance of the primary, secondary, and low-value forage plants and consideration of other factors such as physical damage other than grazing, trampling, prevalence of annuals, etc. (Humphrey, 1949). One advantage of this method is that observations are expressed in general terms rather than percentages. This method is not dependent on an estimate of production.

Weight Measures

In Australia, Beruldsen and Morgan (1934) were among the first to determine utilization by weight when they made comparisons of forage grazed by sheep with that produced under cages or enclosures. The difference in dry weight between the two clippings was the percent utilized. In this procedure, enclosures don't necessarily have to be used. If they are not, similar or paired plots are selected and one of each pair is clipped before grazing and the other after. The difference is considered the amount utilized (Pieper, no date). Both methods are reasonably accurate and reduce personal error. Complications arise if the grazing season coincides with the growing season. Here, it is often necessary to use cages or enclosures to measure growth. Additionally, the variations in use and the heterogeneity of vegetation requires a large number of plots to attain sufficient accuracy and precision.

<u>Height Measures</u>

According to Pechanec and Pickford (1937a), the percentage utilization of grasses is equal to the reduction in their average leaf length (height) as a result of grazing. Enclosures are used if grazing occurs during the period of rapid growth. At the end of the grazing season, the difference in average leaf heights of grazed and ungrazed areas is used to calculate percent utilization.

Pechanec and Pickford (1937a) pointed out that the mechanics of this method are imperfect since it is not dependent on an estimate of production, but involves the erroneous assumption that the volume of grasses varies directly with their height.

Lommasson and Jensen (1938) were the first to correlate height removal with weight removal in range grasses. Variations to this conversion include: (1) charts (Crafts, 1938); (2) circular logarithmic gauges (Lommasson and Jensen, 1943); (3) tables (Collins and Hurtt, 1943); (4) cards with scales printed on them to determine percentage utilization by reading them when they are placed along the side of the plant (Valentine, 1946), and; (5) a slide rule developed from regression equations of stubble height on total height (McArthur, 1951).

The use of average height-weight tables is based on the premise that growth form of grasses is constant between years, seasons, and sites (National Academy of Sciences/National Research Council, 1962).

Stem Count

This method was developed by Stoddart (1935), who concluded that percentage utilization was a direct function of the total number of stems grazed. The method requires a count of grazed and ungrazed stems from a randomized plot. It is a very simple and rapid procedure to use. Its weakness lies with the fact that the percentage of stalks grazed is not always correlated with the percentage of volume taken (Pechanec, 1936). As a result, a conversion factor of stalks grazed to volume utilized at different intensities must be determined for each species measured (Sampson, 1952).

Photographic

On California annual ranges, Hormay and Fausett (1942) determined utilization with photographs and range descriptions. The grazed appearance of the range was compared against a series of photographs showing varying degrees of use (light, moderate, heavy).

The Grazed-Class Method was designed to give accurate, rapid, and consistent estimates of utilization (Schmutz, Holt, and Michaels, 1963). Photo guides of key species are used to place sample plants into one of six utilization classes (0, 10, 30, 50, 70, or 90%). This method uses the key species concept, which assumes that "when one or more key species of an area have been properly utilized in relation to the associated species and the conditions on the range, the best possible use of the area has been made" (Schmutz, 1978, page 2).

Summary of Methods

Each utilization method described has some merit. Some are more rapid or detailed and accurate than others. Additionally, for certain conditions and objectives, some techniques described are more suitable than others. The method used should best fit the purpose of the study, the number of personnel available to conduct the study, and the kind of vegetation.

As utilization techniques have evolved, research has leaned toward learning what constitutes proper utilization i.e., developing utilization standards for each of the important ("key") forage plants and types and developing utilization standards for grazing conditions (National Academy of Sciences/National Research Council, 1962). In the development of these standards, the life histories and requirements of individual plants were first studied. Later, the effects and interactions of different intensities, frequencies, and grazing seasons on the health and vigor of the plants, changes in the plant community, soil compaction, runoff and erosion, animal gains, range condition and trend, and other factors related to grazing were studied. It has been difficult to develop exact standards because of the great variability in plants and the many conditions under which they grow. As a result, the practical aspects of range utilization measurements has led to some question.

Proper interpretation of utilization data depends upon the consideration of several factors:

1. That livestock are not the only animal species responsible for the removal of forage on the range.
2. The need to take utilization measurements soon after grazing has taken place and before regrowth occurs. On areas where grazing is yearlong, it should be measured just before the beginning of the growing season, and possibly several other times as well.
3. That the growth rate is not the same on ungrazed plants as on plants being grazed. Different intensities of grazing can stimulate or slow down production depending on the season grazed, intervals of grazing, and the percent utilization of the plants.
4. That the components being measured can skew results (i.e., standing crop versus total production).
5. That the removal of forage before or after the normal growth period reduces plant vigor less than

grazing during the active growing period.

6. That taking production measurements once a year as opposed to two or more times a year can greatly influence results, especially when plants have more than one growing season. Production should be measured at the end of the growing season. After this time, there is a decline in plant material due to decomposition and consumption by insects, animals, etc.

7. That estimating production from cages can bias results because of cage effect on plant growth and the tendency to include standing dead material. Standing crop and production are not the same thing.

METHODS

Study Area

The study area is located on the Santa Rita Experimental Range located approximately 30 miles south of Tucson. The study site is located in Pasture 302, in the SW 1/4, Section 34, T18S, R15E, of the Gila and Salt River Base and Meridian, on the west facing bajada of the Santa Rita Mountains at an elevation of approximately 1350 meters (see Figures 1 and 2). Pasture 302 has not been grazed by livestock in recent years.

Soils and Range Site

The study area in this pasture is a Whitehouse-Caralampi soil inclusion in a Comoro sandy loam mapping unit at 0 - 30% slope. The Whitehouse sandy loam is a deep, well-drained, reddish-brown soil with a loam surface layer and a moderately fine or fine-textured subsoil. The soil has a high available water holding capacity with good to moderate intake rates. The plant-soil moisture relationship is good. The soil is formed on recent broad alluvial fans derived from the rocks of the Santa Rita Mountains (Richardson, Clemmons, and Walker, 1979). The Caralampi soil series is similar to the Whitehouse soil, but is skeletal. The study area is categorized as a loamy upland range site in a 12- to 16-inch precipitation zone (Richardson et al., 1979).

Climate

The climate of the Santa Rita Experimental Range is

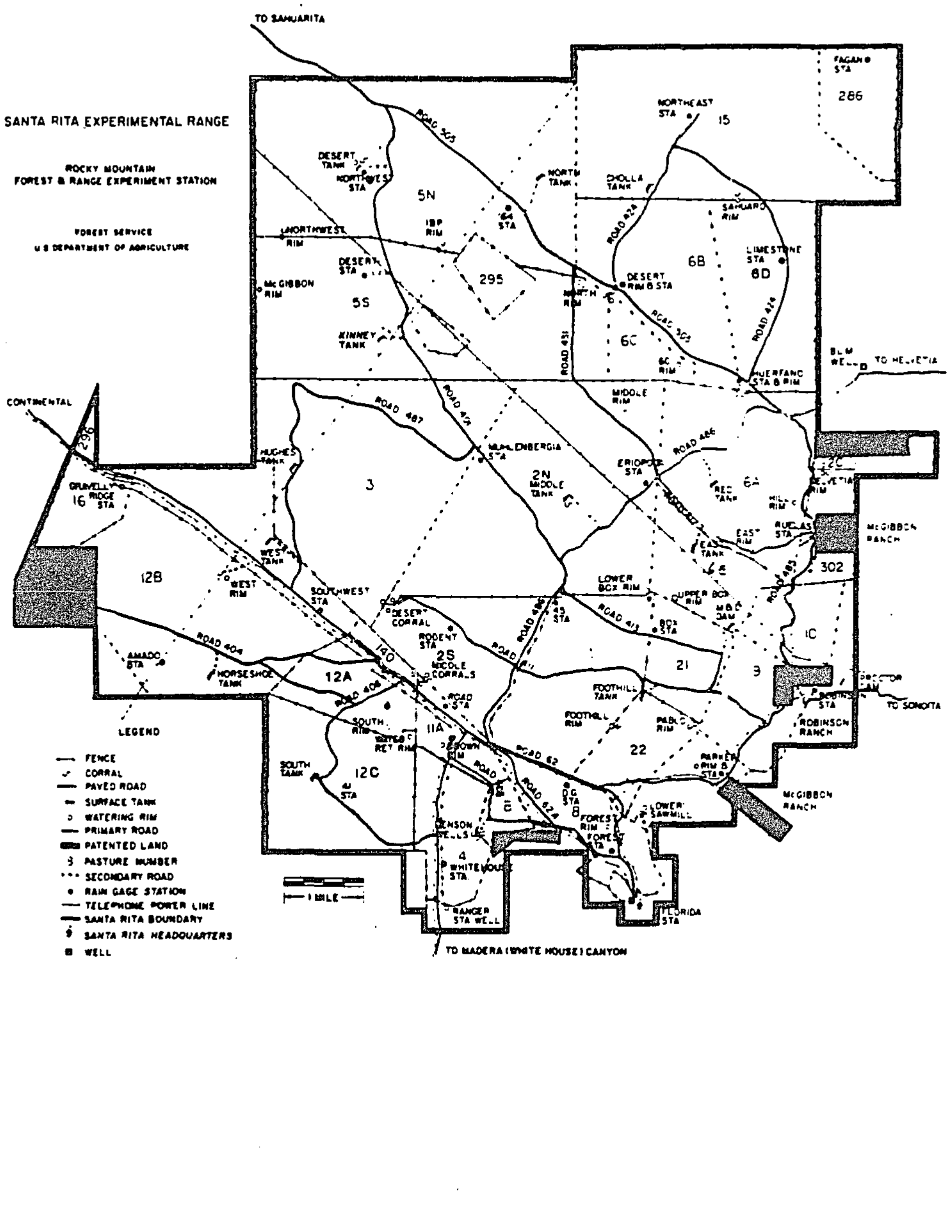
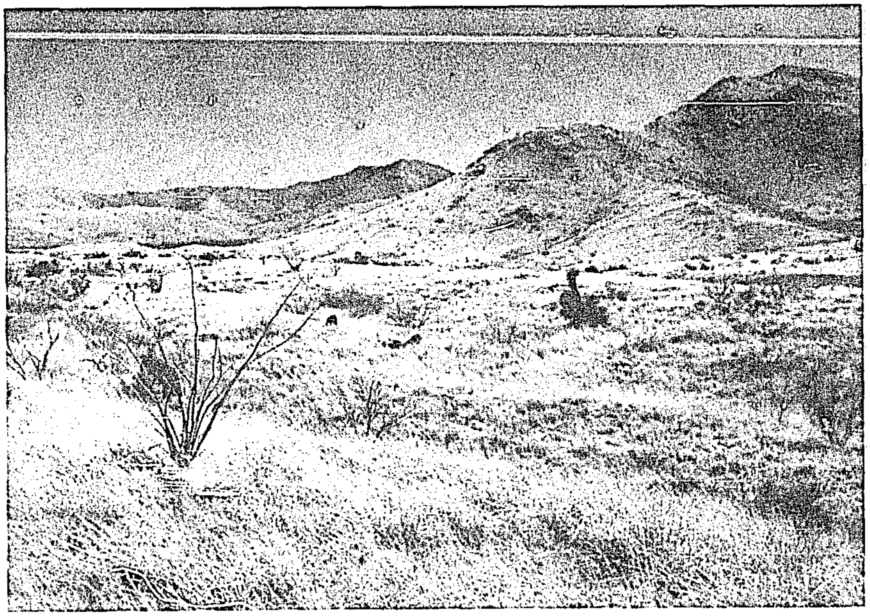


Figure 1. General map of the Santa Rita Experimental Range, southeastern Arizona. The study site is in Pasture 302.



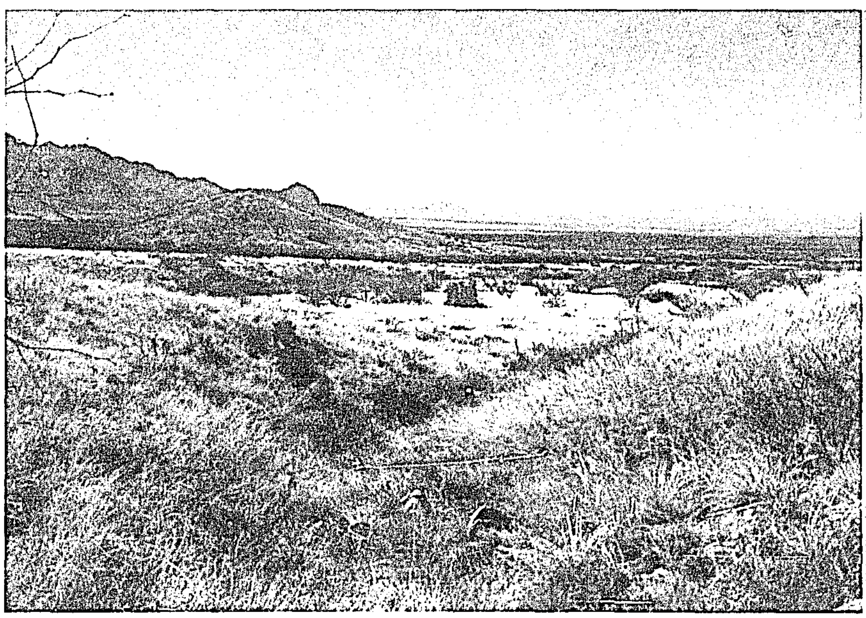


Figure 2. Photographs of clipping site in Pasture 302 looking northeast (top) and southwest (bottom).

semi-arid with precipitation characterized by two distinct rainy seasons (Martin and Reynolds, 1973). Precipitation extremes at the Santa Rita Experimental Range have varied from less than 10 inches (25 cm) to over 30 inches (75 cm) per year (Haile, 1981). At the Ruelas Station (Table 1), precipitation averaged over a four year period was 19.2 inches (48.0 cm) and over a 62-year period was 15.2 inches (38.0 cm). The permanent rain gauge at Ruelas Station is located approximately one-half mile north of Pasture 302. Sixty percent of the rainfall at the Santa Rita Experimental Range falls during the summer growing season (early July to late September) (Cable, 1975). Most of the remainder falls during the winter rainy season from December to April. Freezing temperatures are common at night from December to April, but reach over 100°F in midday in the summer (Martin and Reynolds, 1973). During the winter, temperatures during the day, however, are frequently above 50°F. Occasionally, from December to February, 0°F are recorded for brief periods during some nights. During June, and rarely during July and August, some days exceed 105°F. Frost-free days range from 170 to 230 days. Humphrey (1958) reported that potential evaporation at the Santa Rita Experimental Range averaged 109 inches for a 14-year period. High wind speed, high temperatures, and low relative humidities account for much of the high evaporation rate.

Table 1. Precipitation data (in inches) from January 1983 to May 1987 and 62-year average at Ruelas Station, Santa Rita Experimental Range.

	YEAR					
	1983	1984	1985	1986	1987	62-Year Average
MONTH						
January	2.52	1.42	2.24	0.00	0.47	1.03
February	1.40	0.00	1.07	2.19	1.72	0.95
March	1.88	0.00	0.29	0.50	0.50	0.81
April	0.74	1.02	0.82	0.29	1.38	0.37
May	0.15	0.02	0.12	0.42	1.27	0.11
June	0.00	1.68	0.04	0.46		0.47
July	2.98	4.05	3.58	2.48		3.51
August	3.89	4.57	1.58	7.06		3.32
September	5.63	2.92	1.58	0.62		1.72
October	2.63	1.35	2.51	0.92		0.90
November	1.38	0.69	0.98	0.39		0.86
December	0.67	3.31	0.23	1.67		1.12
TOTAL	23.87	21.03	15.04	17.00		15.22

Plant Communities

Species found on the study site are listed in Appendix Table A-1 with scientific plant names from Kearney and Peebles (1969). Data from Pasture 302 on the loamy upland range site represents the plant community when protected from livestock grazing. Plant species composition by weight for the most common species on the study site were as follows: for the grasses, Bouteloua curtipendula was 15%, Trichachne californica 10%, Andropogon barbinodis 10%, Eragrostis intermedia 10%, and Bouteloua eriopoda 10%. The predominant shrub was Calliandra eriophylla at 10% composition. Species were recorded in the spring and summer, when most species occurring on the site could be observed, including annual forbs.

Experimental Approach

One hundred twenty-five individual sideoats grama plants were located on the study area and marked with survey stakes. Sideoats grama plants used in this study were selected from plants of a 9- to 20-centimeter diameter class (4-8 inches). Plants were divided into ten groups based on their basal diameter (Table 2). In each of these groups, plants were randomly assigned a treatment number from 1 through 12 based on the three simulated utilization levels and four seasons.

The three simulated utilization levels included: control (all material removed above ground - 100%

utilization), moderate [clipped to 16 cm stubble height - approximately 40% utilization based on photo guides (Schmutz, 1978)], and heavy (clipped to 8 cm stubble height - approximately 70% utilization based on photo guides). Seasonal sampling dates were used to monitor production and utilization estimates over time. These consisted of April, 4, 1986 to represent plant conditions at the end of the spring growing period; June 30, 1986, as the end of the spring dry period; October 3, 1986, as the end of the summer-fall growth period; and February 27, 1987, as the end of the winter dormancy period. To facilitate clipping and sampling efforts, all clipping treatments were identified in the field by a numbered stake located 6 inches downhill from the treatment plant (see Figure 3). Out of 125 plants staked, 120 plants were randomly selected for treatment. Ten plants were clipped per treatment. Within each treatment, standing dead herbage was collected and weighed along with live sideoats grama plant material. All clipped herbage was air dried and weighed to detetermine seasonal productivity of sideoats grama in response to clipping treatments.

Treatments clipped in April 1986 and June 1986, were reclipped in October 1986. The treatment clipped in October 1986 was also reclipped in February 1987. Reclippings allowed for the analysis of regrowth and total production comparisons as a result of utilization at different seasons.

Table 2. Basal area of sideoats grama plants assigned to each of ten groups.

GROUP	BASAL DIAMETER RANGE
1	9.00 - 10.50 cm
2	10.50 - 11.50 cm
3	11.50 - 12.00 cm
4	12.00 - 13.00 cm
5	13.00 - 13.50 cm
6	13.50 - 14.50 cm
7	14.50 - 15.00 cm
8	15.00 - 16.00 cm
9	16.00 - 17.50 cm
10	>18.00 cm

Figure 3. Photographs of clipped plants and sample number stakes.

Sample Preparation

All clipped herbage was placed in a paper bag and air dried. Samples were then separated into standing dead herbage or live plant material. When October and June treatments were reclipped, regrowth was also separated and weighed. The weight of each individual component of the individual plants, as well as their total weight, was recorded in grams.

Data Analysis

Data were analyzed through the use of Analysis of Variance and significance among means designated by Least Significant Difference (LSD). (Refer to ANOVA tables in Appendix Tables A2 to A5.) Comparisons among intensity of clipping and seasonal weights were made for current year's growth, standing dead material, and total standing crop as gms/plant based on seasonal removal. The correlation of plant weight with basal area was also examined. Comparisons of regrowth as gms/plant based on season and intensity of clipping were also determined.

Percentage utilization data were calculated for each replication by dividing the gms/plant for moderate and heavy clipped plants for each season by the gms/plant for control plants. These calculations were made for both current growth and total standing crop data. Percentage data were analyzed by ANOVA without transformation.

The utilization value which best fits the Glossary Revision Special Committee, Publications Committee, Society for Range Management's (1989) definition of utilization is gms/plant removed by a clipping treatment divided by the control current growth at peak standing crop (October for this study). These utilization values were identified as actual utilization based on current growth and are used as the reference for all other utilization estimates. Utilization estimates which were calculated by using the peak standing crop are designated as actual utilization -total standing crop. Relative utilization are percentages calculated by using clipped gms/plant divided by the control (current or total standing) clipped at the time of the seasonal clipping treatment.

RESULTS AND DISCUSSION

Both total standing crop and current growth have been used separately by range managers to estimate utilization, yet these two estimates can result in significantly different results. In addition to this, the effects of seasonal variability on these estimates can also alter results. Variability in rainfall, temperature, wind, grazing intensity, etc. throughout the seasons can greatly affect the amount of plant material on a site.

Correlation of Plant Weight with Basal Area

There was a good correlation between the average basal diameter of plants and the average weight of the plant material clipped for current growth, standing dead, and total standing crop. Table 3 shows the average basal area diameter and grams for current growth, standing dead, and total standing crop. The basal diameter of a grass plant often is a reflection of the size and amount of plant material within the plant. The linear regressions were $y = -14.60 + 12.34x$ ($R^2 = .90$) for current growth, $y = -30.70 + 3.80x$ ($R^2 = .85$) for standing dead material, and $y = -45.20 + 6.14x$ ($R^2 = .87$) for total standing crop (Appendix Table A-2). These correlations explain the significant block effects in ANOVAs (Appendix Table A-3) and verify that a block design is appropriate for clipping studies with individual plants as the sample unit.

Table 3. The average basal diameter of sideoats grama plants (cm) and the average weight of plant material (gms/plant) clipped over seasons and clipping treatments in each of the ten plant size groups for total standing crop, standing dead material, and current growth.

GROUP	AVERAGE BASAL DIAMETER	TOTAL STANDING CROP	STANDING DEAD MATERIAL	CURRENT GROWTH
1	9.75	19.60	10.20	9.40
2	11.00	26.00	12.60	13.40
3	11.75	27.70	14.50	13.10
4	12.50	31.30	16.90	14.50
5	13.25	29.00	15.50	13.50
6	14.00	39.40	21.70	17.70
7	14.75	40.90	21.90	19.00
8	15.50	45.40	25.80	19.60
9	16.75	52.30	28.60	23.80
10	18.00	78.50	47.00	31.50
AV.MEAN		39.01	21.46	17.56

Clipped Herbage

Analyses of Variance (ANOVA) showed statistically significant differences in amount of clipped current growth, standing dead, and total standing crop at four different seasons and at three different intensities (moderate, heavy, and control) ($P < 0.05$) (Appendix Table A-3). Additionally, there were no statistically different interactions between clipping intensity and season clipped. Results, therefore, are discussed for main effect means except clipped herbage data for control plants are discussed by season to show their variation as base values to calculate percentage utilization.

Seasonal Estimate When Clipped to Ground Level

Figure 4 shows data for total standing crop and current growth of "control" plants for four different dates (April, June, October, and February) when clipped to ground level. Peak total standing crop occurred in October with an average of 74 grams/plant. Current growth also peaked in October with an average of 38 grams/plant. Current growth, total standing crop, and peak standing crop data are shown in Appendix Table A-4. Current growth ranged from a low of 14 grams/plant in June to a high of 38 grams/plant in October. Spring growth was approximately 39% of total peak production. Heavy precipitation in August of 1986 (Table 1) accelerated the growth of live herbage, and also accounted for losses of standing dead material. Studies done by Cable (1975) on the

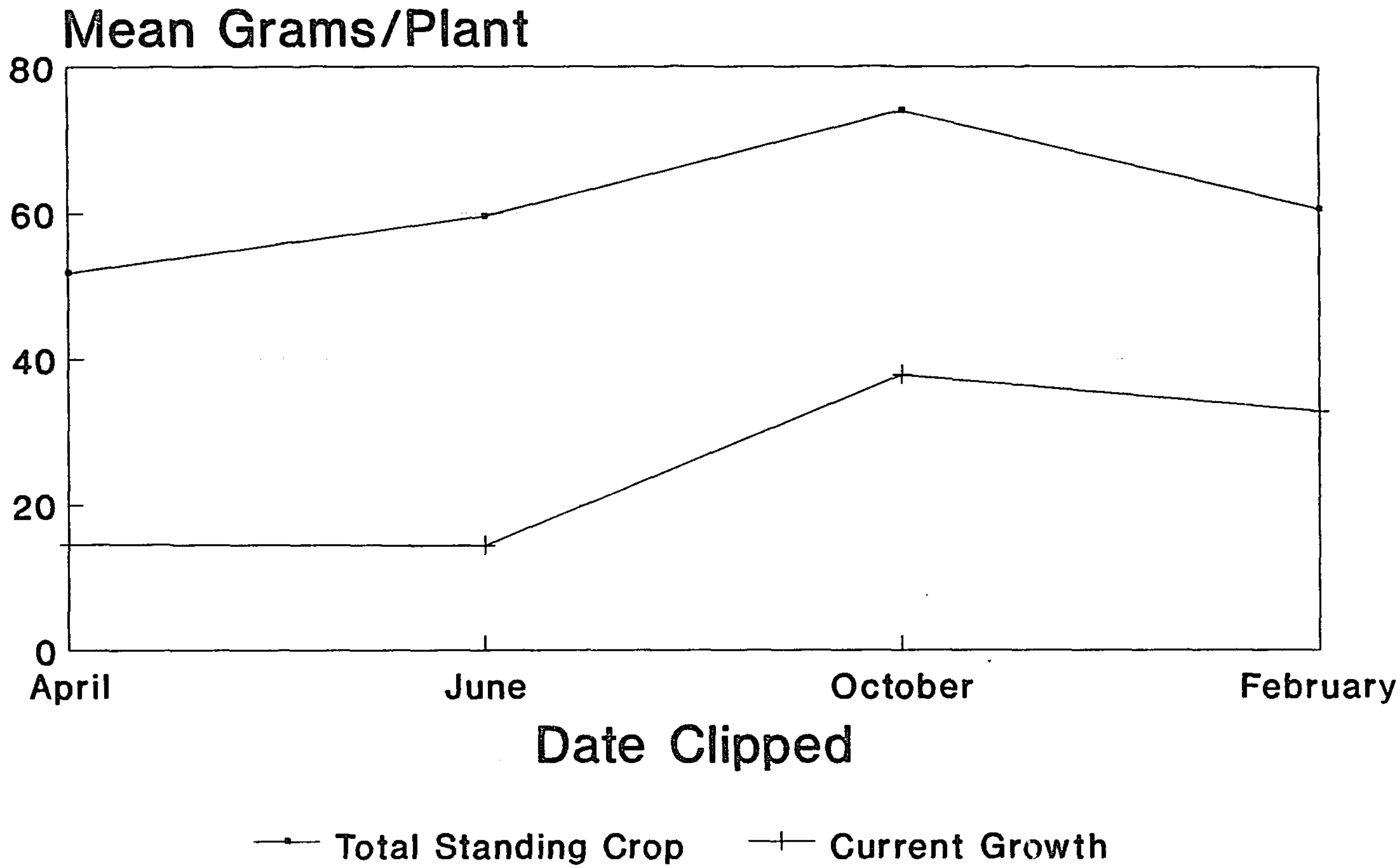


Figure 4. Total standing crop and current growth of sideoats grama at four different seasons.

influence of precipitation on perennial grass production at the Santa Rita Experimental Range in southern Arizona showed that 64 to 91 percent of the year to year variation in native perennial grass production could be accounted for by variations in the June-September rainfall of the previous year and current August rainfall.

The growth rate of sideoats grama was directly related to precipitation with a dry period between April and June and summer precipitation between July and August as shown in Table 1. The favorable precipitation in July and August triggered growth to produce the peak standing crop in October. Current growth declined slightly from April to June and was at a low point during June. The opposite was true for standing dead material. For the months of April and June, the amount of current growth in the total standing crop was only 28% and 24%, respectively. In October and February, however, current growth made up over half of total standing crop at 51% and 54%, respectively.

Total standing crop ranged from a low of 52 grams/plant in April to a high of 74 grams/plant in October. When standing dead material was highest (June), current growth was lowest, yet current growth often is assumed to be high in June because of the high amount of standing dead material within the plant. The opposite was true for current growth. When it was highest (October), standing dead material was declining. Standing dead material was only about equal in amount to current growth beginning in October and declined toward February. In separating the two measurements from one another based on estimation or in using total standing crop to base utilization estimates, results can become highly biased. To make the most accurate utilization estimates, current growth should be separated from total standing crop and be measured at the end(s) of the growing season(s). The current growth of October is considered peak standing crop but is an underestimate of production because it doesn't take into consideration natural losses of current production during the growth period. Often, estimates of production for a plant community also do not take into account the fact that individual species reach peak production at different times of the year and losses occur differently by detachment of plant parts for each species throughout the year (Weigert and Evans, 1964).

Current Growth

Clipping Intensity

The mean harvested herbage from moderately clipped plants was 12 gms/plant, from heavily clipped plants, 16 gms/plant, and from the control clipped plants, 25 gms/plant (Table 4). This would be expected since more of the plant was removed as utilization increased and more current growth was located at the basal area of the plant. These data are means averaged over season of removal.

Table 4. Clipped sideoats grama herbage as grams per plant for three clipping intensities and four seasons.

	MONTH				
INTENSITY	APRIL	JUNE	OCTOBER	FEBRUARY	MEAN
CURRENT GROWTH					
MODERATE	2.0	2.3	28.1	14.2	11.6c*
HEAVY	6.6	8.8	26.8	22.0	16.1b
GROUND LEVEL	14.6	14.5	37.8	32.9	24.9a
MEAN	7.7c	8.5c	30.9a	23.0b	
LSD FOR COLUMN MEANS = 4.5			LSD FOR ROW MEANS = 3.9		
STANDING DEAD					
MODERATE	10.5	11.1	11.0	5.5	9.5c
HEAVY	20.5	29.3	11.5	11.7	18.2b
GROUND LEVEL	37.2	45.1	36.2	27.7	36.6a
MEAN	22.7b	28.5a	19.6bc	15.0c	
LSD FOR COLUMN MEANS = 5.7			LSD FOR ROW MEANS = 4.9		
TOTAL STANDING CROP					
MODERATE	12.5	13.4	39.1	19.7	21.2c
HEAVY	27.1	38.1	38.4	33.7	34.3b
GROUND LEVEL	51.9	59.6	74.1	60.6	61.5a
MEAN	30.5b	37.1b	50.5a	38.0b	
LSD FOR COLUMN MEANS = 8.2			LSD FOR ROW MEANS = 7.1		

* Means with the same letter in a row or within a column for each kind of standing crop are not significantly different at the 0.05 level of significance.

Season

Both October and February clippings were significantly different from April and June (Table 4). Spring growth occurred prior to April due in part to 2.19 inches of rainfall in February 1986 (Table 1), and this amount of standing current growth remained stable through the spring dry period. Current growth increased again by October, 1986 due to July and August rainfall and declined through the winter dormancy period to February, 1987. This was true independent of the intensity of the clip.

Regrowth

Moderate Clipping Intensity

When the clipped herbage of April plus April regrowth and June plus June regrowth were calculated under moderate clipping, grams/plant were lower than for plants clipped only in October (Table 5). Moderate clipping reduced annual production compared to a single clipping in October at peak standing crop.

Heavy Clipping Intensity

When the clippings of April plus April regrowth and June clipped herbage plus June regrowth were calculated under heavy clipping, grams/plant were higher than the October clipping (Table 5). Heavy clipping stimulated production therefore, control plants clipped only in October were a low estimate of actual production for this treatment.

Generally, it should be noted, however, that heavy

Table 5. Current growth herbage of sideoats grama as grams per plant clipped in April and June at three intensities plus regrowth compared to current growth of control plants clipped only in October.

	CLIPPING INTENSITY		
MONTH	MODERATE	HEAVY	GROUND LEVEL
APRIL			
INITIAL CLIP	2.0	6.6	14.6
REGROWTH	23.9	30.3	15.7
TOTAL	25.9	36.9	30.3
JUNE			
INITIAL CLIP	2.3	8.8	14.5
REGROWTH	24.7	32.7	15.4
TOTAL	27.0	41.5	29.9
OCTOBER			
MEAN FOR CONTROL PLANTS			37.8

clipping over time usually results in a marked decline of forage vigor (Parker and Sampson, 1931; Biswell and Weaver, 1933). Since forage in Pasture 302 had not being grazed for many years, heavy clipping stimulated production. Production likely would eventually decrease if heavy clipping continued. Cook and Stoddart (1953) found that for all seasons that there was an increase in the percentage of plants killed and a reduction in living crown cover of plants as the intensity of herbage removal was increased. They found that 75% of forage removed was significantly more harmful than 50% removal.

Control Clipping Intensity

The April harvested herbage plus April regrowth as grams/plant values were lower than for the October only clipping. Clipping 100% in this case, did not stimulate production. As a result, October's unclipped plants were a high estimate of actual annual production for this severe clipping treatment. Similar results were found for the June clip plus June regrowth values (Table 5).

Regrowth Summary

Depending on whether clipping does or does not stimulate plant production based on the intensity of the clip, one could overestimate or underestimate plant production using October's peak standing crop value and as a result, underestimate or overestimate utilization for a specific treatment. Yield from two or more clippings which is larger than the annual peak yield could indicate a stimulation of production due to clipping during the growing season, or it could also indicate the loss of green growth from plants clipped only at peak production due to natural occurrences or conversion to standing dead material. Thus, detailed studies are needed to determine whether the sum of multiple clippings or peak current yield are the best estimate of annual production to use as the base value for calculating actual utilization.

Standing Dead Material

Clipping Intensity

The moderately clipped plants yielded a mean value of 10 gms/plant, the heavily clipped plants had a mean value of 18 gms/plant and the control plants had a mean value of 37 gms/plant (Table 4). Again, as expected with current growth, this was a result of more of the plant being removed as utilization increased and more standing dead material being located at the basal area of the plant. This trend was true regardless of the season of removal.

Season

There were also statistically significant differences between the June mean value of 29 gms/plant and April mean value of 23 gms/plant. These data indicate that at least 6 grams of current growth dried and became classified as standing dead herbage during April to June even though current growth appeared nearly constant. New growth was replacing that which was taking on a dead appearance (Table 4). Results also showed statistically significant differences between the October and June seasons of removing standing dead material. Summer was the time of major loss of standing dead material. Results were not statistically different, however, between October and February when loss occurred but not as much as in the summer.

Total Standing Crop

Clipping Intensity

As utilization increased for current growth and standing dead, more of the plant was removed as more plant material was located at the basal area of the plant (Table 4).

Season

Results were not significantly different among the February, June, and April seasons. This was because plants in April and June had the least amount of current growth and highest amounts of standing dead material equaling total standing crop values not significantly different from February values of low current growth and high amounts of standing dead material. Plants clipped in October had the highest amount of material and represent peak total standing crop (Table 4).

Utilization Estimates

Comparisons were made between relative and actual utilization. Relative utilization was based on standing crop (current production or total standing) at a time when the utilization estimate was made and is a reflection of standing crop at that point in time. Actual utilization was based on the best estimate of peak standing crop and was reflective of this value. The October value was used to represent peak standing crop.

Examining the clipping of current growth at four different seasons and two intensities (moderate and heavy) for actual utilization showed statistically significant differences ($P < 0.05$) among seasons (Table 6). April and June estimates of utilization were generally lower than October and February estimates, signficantly so for actual and relative utilization estimates based on current growth. There were no significant interactions between clipping intensity and season clipped (Appendix Table A-5). Differences between moderate and heavy clipping were statistically significant and relatively consistent among all the methods of calculation (Table 6).

Actual utilization estimates in April and June were 11 and 14%, respectively (Table 6). Relative utilization estimates using current growth provide estimates of 33 and 38%, respectively, which are three times greater than actual utilization. Actual utilization based on total standing crop provided estimates similar to relative utilization current growth estimates. Estimates of utilization in April and June using relative total standing crop resulted in utilization estimates four times higher than actual utilization.

These results confirm that if caged plots clipped at the time of the utilization estimate or stubble-height methods

Table 6. Percentage utilization estimates for sideoats grama plants for two intensities of clipping at four seasonal dates using various methods of calculation.

CALCULATION METHOD	MONTH				
INTENSITY	APRIL	JUNE	OCTOBER	FEBRUARY	MEAN
ACTUAL UTILIZATION - CURRENT GROWTH					
MODERATE	5.5	5.5	78.5	42.8	33.1b*
HEAVY	17.4	22.7	78.6	64.0	45.6a
MEAN	11.4c	14.1c	78.6a	53.4b	
LSD FOR COLUMN MEANS = 14.8			LSD FOR ROW MEANS = 10.5		
RELATIVE UTILIZATION - CURRENT GROWTH					
MODERATE	17.3	13.9	78.5	54.9	41.2b
HEAVY	49.3	62.9	78.6	85.8	69.2a
MEAN	33.3b	38.4b	78.6a	70.3a	
LSD FOR COLUMN MEANS = 26.4			LSD FOR ROW MEANS = 18.7		
ACTUAL UTILIZATION - TOTAL STANDING CROP					
MODERATE	21.9	19.2	57.2	35.2	33.4b
HEAVY	38.5	49.3	62.5	50.2	50.1a
MEAN	30.2b	34.3b	59.9a	42.7b	
LSD FOR COLUMN MEANS = 12.6			LSD FOR ROW MEANS = 8.9		
RELATIVE UTILIZATION - TOTAL STANDING CROP					
MODERATE	28.8	23.0	57.2	52.7	40.4b
HEAVY	53.2	65.3	62.5	66.2	61.9a
MEAN	41.0a	44.1a	59.9a	59.4b	
LSD FOR COLUMN MEANS = 19.1			LSD FOR ROW MEANS = 13.5		

*Means with the same letter in a row or within a column for each method of calculation are not significantly different at the 0.05 level of significance.

correlated with total peak standing crop had been used in the utilization analysis of Pasture 302 prior to plants reaching peak growth (October), utilization would have been greatly overestimated.

For utilization estimates made in October, actual utilization is underestimated if based on total standing crop. Results show that any method using total standing crop as the base for determining utilization will underestimate utilization at time of peak standing crop.

Actual utilization estimates based on total standing crop in February were lower (43%) than actual utilization estimates based on current growth (53%), but actual utilization based on current growth provided similar estimates to the relative utilization estimates for total standing crop (59%) (Table 6). Estimates of utilization in February using relative current growth as a base (70%) resulted in utilization estimates higher than actual current growth (53%). Results show that if the caged method had been used in February, the use of total standing crop would have given a more comparable estimate to actual utilization based on peak current yield than by separating out current growth.

CONCLUSIONS

Conclusions from this study are as follows:

1. The total standing crop and current annual growth weight of sideoats grama plants was strongly correlated with plant basal diameter.
2. Thirty-nine percent of the peak current growth production of sideoats grama occurred in the spring of 1986.
3. Current growth was at its highest in October and lowest in June; standing dead material was at its lowest in February and highest in June. Total peak standing crop occurred in October.
4. The sum of initial clip current growth and regrowth of heavily clipped plants was greater than for control plants (October clipping), but the sum of clipped current growth and regrowth for moderate and control clipping was less than for control plants clipped only in October. Sideoats grama plants had not been clipped for several years.
5. In April and June, relative utilization based on current growth or total standing crop and actual utilization based on total standing crop all overestimated actual utilization based on current growth.
6. For utilization estimates made in October, actual utilization for current growth was underestimated

based on total standing crop.

7. Actual utilization estimates based on total standing crop in February were lower than for estimates based on current growth. Utilization based on relative current growth estimates were highest of all estimates. Actual utilization based on current growth, however, was similar to relative utilization estimates based on total standing crop.

APPENDIX A.
SCIENTIFIC NAMES OF PLANTS, ANALYSES OF VARIANCE TABLES, AND SUMMARY DATA FOR CONTROL PLANTS

Table A-1. A list of scientific and common names of species at the study site, Santa Rita Experimental Range, Pasture 302.

Scientific Name	Common Name
Bouteloua curtipendula (Michx.)	Sideoats grama
Trichachne californica (Benth) Chase	Arizona Cotton-top
Andropogon barbinodis Lag	Cane Beardgrass
Eragrostis intermedia Hitchc.	Plains Lovegrass
Bouteloua eriopoda Torr	Black Grama
Bouteloua filiformis (Fourn) Griffiths	Slender Grama
Leptochloa dubia (H.B.K.) Nees	Green Sprangletop
Bouteloua hirsuta Lag	Hairy Grama
Aristida ternipes Cav	Spidergrass
Muhlenbergia porteri Scribn	Bush Muhly
Heteropogon contortus (L.) Beauv	Tanglehead
Setaria macrostachya (H.B.K.)	Plains Bristlegrass
Bouteloua chondrosiodes (H.B.K.) Benth	Sprucetop Grama
Lycurus phleoides (H.B.K.)	Wolftail
Eragrostis lehmanniana Nees	Lehmann Lovegrass
Calliandra eriophylla Benth	False Mesquite
Acacia greggii Gray	Catclaw Acacia
Prosopis juliflora (Swartz) DC	Mesquite
Gnaphalium sp.	Cud Weed
Chenopodium sp.	Lamb's Quarter
Eriogonum wrightii Torr	Shrubby Buckwheat
Sida procumbens	Sida
Baccharis sp.	Little Leaf Bacch.
Boerhaavia coccinea Mill.	Trailing 4-o'clock
Cirsium sp.	Thistle
Opuntia fulgida Engelm.	Chain fruit cholla
Yucca sp.	Yucca
Ferocactus sp.	Barrel Cactus
Fouquieria splendens Engelm.	Ocotillo
Opuntia sp.	Prickly Pear

Table A-2. Analysis of variance including mean squares attributed to linear regression for total standing crop, standing dead material, and current growth where x is equal to the average basal diameter of the plants (cm) and y is equal to the average weight of the plant (gms).

STANDING DEAD MATERIAL

	DF	MS	F	P
Total	9			
Regression	1	875.43	44.37	.00
x^1	1	875.43	44.37	.00
Error	8	19.73		

Regression Equation: y= -30.70 + 3.80*x^1
R^2 = 0.85

CURRENT GROWTH

	DF	MS	F	P
Total	9			
Regression	1	332.33	72.23	.00
x^1	1	332.33	72.23	.00
Error	8	4.60		

Regression Equation: y = -14.60 + 2.34*x^1
R^2 = 0.90

TOTAL STANDING CROP

	DF	MS	F	P
Total	9			
Regression	1	2279.72	54.52	.00
x^1	1	2279.72	54.52	.00
Error	8	41.81		

Regression Equation: y = -45.20 + 6.14*x^1
R^2 = 0.87

Table A-3. ANOVA for total standing crop, standing dead material and current growth calculated at four different seasons and three different clipping intensities.

TOTAL STANDING CROP

	DF	MS	F	P
Block (Basal Area)	9	3481.34	13.58	.00
Clip (C)	2	16939.70	66.07	.00
Month (M)	3	2098.11	8.18	.00
Interaction (CxM)	6	280.46	1.09	.37ns
Error	99	256.38		
Total	119			

STANDING DEAD MATERIAL

	DF	MS	F	P
Block (Basal Area)	9	1376.13	11.21	.00
Clip (C)	2	7618.59	62.05	.00
Month (M)	3	973.11	7.93	.00
Interaction (CxM)	6	263.59	1.33	.25ns
Error	99	122.79		
Total	119			

CURRENT GROWTH

	DF	MS	F	P
Block (Basal Area)	9	489.07	6.26	.00
Clip (C)	2	1837.86	23.52	.00
Month (M)	3	3857.88	49.38	.00
Interaction (CxM)	6	62.14	0.80	.58ns
Error	99	78.13		
Total	119			

Table A-4. Total standing crop, standing dead material, and current growth of control plants at four different seasons.

	MEAN GRAMS/PLANT		
	TOTAL STANDING CROP	STANDING DEAD MATERIAL	CURRENT GROWTH
DATE CLIPPED			
APRIL 4, 1986	51.86	37.23	14.63
JUNE 30, 1986	59.62	45.13	14.49
OCTOBER 3, 1986	74.06	36.24	37.82
FEBRUARY 27, 1987	60.58	27.71	32.87
MEAN	61.53	36.58	24.95

Table A-5. ANOVA for actual and relative utilization for total standing crop and current growth calculated at four different seasons and two different clipping intensities (moderate and heavy).

ACTUAL UTILIZATION - CURRENT GROWTH

	DF	MS	F	P
Block (Basal Area)	9	1306.82	2.37	.02
Clip (C)	1	3146.29	5.71	.02
Month (M)	3	21014.25	38.15	.00
Interaction (CxM)	3	418.08	0.76	.52ns
Error	63	550.84		
Total	79			

RELATIVE UTILIZATION - CURRENT GROWTH

	DF	MS	F	P
Block (Basal Area)	9	1334.32	0.76	.65ns
Clip (C)	1	15666.00	8.97	.04
Month (M)	3	10246.32	5.87	.00
Interaction (CxM)	3	2077.80	1.19	.32ns
Error	63	1746.32		
Total	79			

ACTUAL UTILIZATION - TOTAL STANDING CROP

	DF	MS	F	P
Block (Basal Area)	9	1788.75	4.50	.00
Clip (C)	1	5614.60	14.11	.00
Month (M)	3	3455.95	8.69	.00
Interaction (CxM)	3	516.51	1.30	.28ns
Error	63	397.83		
Total	79			

RELATIVE UTILIZATION - TOTAL STANDING CROP

	DF	MS	F	P
Block (Basal Area)	9	999.09	1.09	.38ns
Clip (C)	1	9206.34	10.05	.00
Month (M)	3	1978.47	2.16	.10ns
Interaction (CxM)	3	1275.29	1.39	.25ns
Error	63	916.26		
Total	79			

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