Grazed-class Method of Estimating Forage Utilization[1]

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Obtaining proper forage utilization, and its measurement, are essential parts of good range management. Proper stocking is the most important single practice influencing the proper use of the range. In fact, proper stocking is so essential to proper range use that the terms are frequently used interchangeably.

Determination of proper stocking and/or proper range use has been attempted by various methods. Long-time proper stocking rates have been estimated by averaging yearly stocking records, by using range survey methods, by classifying range conditions which are correlated with grazing capacities, and by forage weighing and estimating procedures. These estimates are useful mainly in determining starting stocking rates or as average guides since production on a particular range may vary from year to year. Amount and distribution of seasonal rainfall, temperature variations and wind movements, changes in plant vigor and range condition, application of fertilizers and nutrient availability, rainfall during the previous season of growth, and/or grazing intensity and frequency during previous seasons all affect production. Short-time annual or seasonal adjustments in range use have been based largely on measurements of forage grazed or herbage left. These short-time measurements are the most important and, in time, will furnish the most accurate data on long-time or average stocking rates.

Range utilization is closely correlated with and has a direct short-time effect on range trend, a long-time effect on range condition, and both a short- and long-time effect on forage density and range productivity. Other factors influenced by range use are soil erosion; water yield and runoff; vigor and reproduction of important forage, timber and weed species; litter accumulation; trampling of forage plants by livestock; and recreation and wildlife values.

The major problem in determining utilization is the actual measurement or estimation of the percentage or amount of the plant utilized. Direct measurement of forage consumed is difficult so most methods rely on determination or estimation of the forage left in relation to measured or reconstructed production, the assumption being that the missing forage has been eaten by livestock. In addition there is considerable variation in the accuracy and use of the various methods used to measure plant height, weight or numbers grazed. Regrowth of grazed plants also complicates estimation of degree of use.

Other problems influencing range utilization are differences in palatability and aggressiveness of associated species; variations in forage preference by different classes of stock; differences in the amount of grazing various plants can withstand; difficulties in selecting key plants and key areas upon which to make utilization estimates; differences in accessibility of areas to livestock grazing; variations in slope and susceptibility of the soil to erosion; differences in location and frequency of livestock water; and variabilities in size and shape of pastures.

In spite of all these difficulties, or maybe because of them, numerous methods have been devised to estimate or measure forage utilization. Reviews of various methods have been made by Pechanec and Pickford (1937); Campbell (1943); Dasmann (1948); Heady (1949); Humphrey (1949); Joint Committee-ASA, ADSA, ASAP, ASRM (1952); Parker (1952); Sampson

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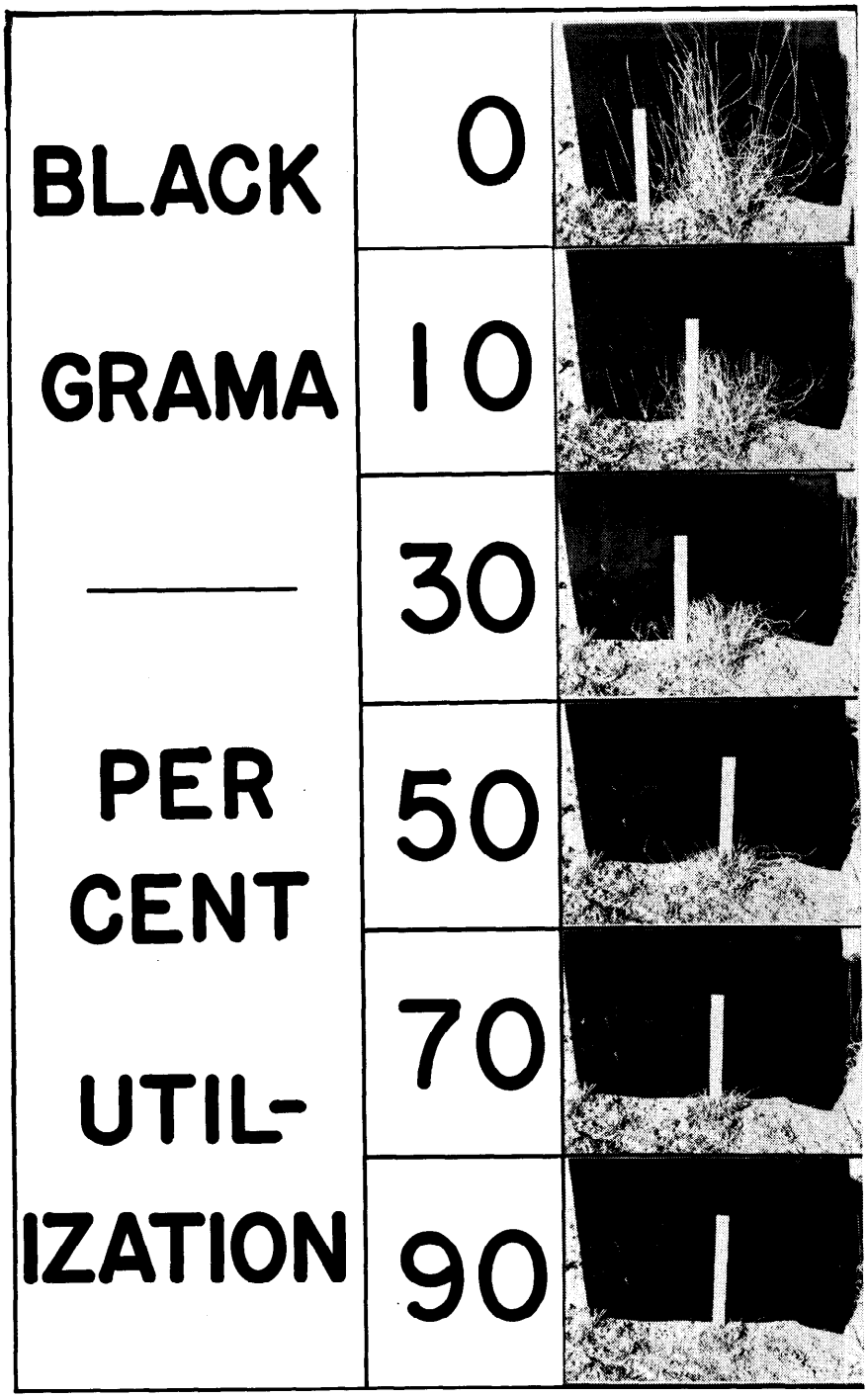

FIGURE 1. Photographic grazed-class guide for estimating forage utilization.

(1952); Brown (1954); Stoddart and Smith (1955); Hedrick (1958); U. S. Forest Service (1959); and Joint Committee-ASRM, Agricultural Board (1962). Some of these methods have been devised mainly for quantitative research measurements and others for qualitative management purposes. Some have broad application to a large variety of species and vegetative types; others are restricted to particular classes of plants with specific growth forms. Some methods are rapid and provide data from extensive areas while others are tedious and can be used only on representative or indicator areas. Whether a universal method can be developed is questionable.

In an attempt to develop a fast, accurate, statistically sound method of measuring forage utilization; useable by both ranchers and technicians; the grazed-class method was developed.

The Grazed-Class Method

The grazed-class method combines the advantages of several methods. Photographic guides, based on locally developed height-weight curves, are set up in card form for each key species (Figure 1). The guides are developed by clipping and photographing plants of average growth form to represent 0, 10, 30, 50, 70 and 90 percent use. Using these guides the examiner places up to 100 plants of each key species, located by toe-pace transects, into their appropriate grazed-classes (Table 1). Data for each key species are recorded separately although evaluations of two or more species may be made simultaneously. The percentage utilization for each species is determined by multiplying the average precentage use of each grazed-class by the percentage of grazed plants in each grazed-class and totaling the products.

Sampling Procedures

Proper sampling of a grazed pasture is essential if estimates of range use are to be reliable. Key areas may be sampled where they represent a true index to the overall use in the pasture (Sampson, 1952; and Stoddart and Smith, 1955). However, where marked variations in use occur due to site differences, topography or water distribution, the pasture may need to be subdivided for sampling purposes. This procedure was found by Costello and Klipple (1939) to increase the accuracy of sampling density. The simplicity and speed of the grazed-class method makes it adaptable to rapid sampling of several areas.

Estimates may be made at mechanically determined, uniform intervals along sampling lines or at random points in pre-selected locations representative of the area. One to several estimates may be made for each species at each location and totaled for the area. For simplicity in conversion to percentages, composite totals of 20, 25, 50 or 100 estimates may be made for each key species in each pasture or subdivision of the pasture.

Ordinarily from one to three key species are adequate to estimate utilization. Where more than one key species is used to estimate utilization, the percentage composition of each key species in the forage type must also be estimated or obtained from range survey records. This estimation of percentage composition introduces a possible source of error and calculations are increased slightly which may or may not be offset by the introduction of a larger vegetative sample on which to base use estimates.

Calculation of Grazing Use

Current percentage utilization is calculated for each key species as indicated in Table 1. If current use of a species is 43 percent and its proper use is 50 percent then the difference is the forage units remaining. If the cow-months (CM) of current use are known, e.g. 60 head for 10 months, the remaining use may be calculated according to procedures outlined by Stoddart and Smith (1943) or Sampson (1952):

Table 1. Grazed-classes and method of calculating current use by the grazed-class method of estimating utilization.

Descriptive names of grazed-classes	Range of utilization by grazed-classes	Average utilization by grazed-classes	Plants by grazed-classes	Current utilization
		(Percent)		
Ungrazed	0	0	4	0
Slight use	0- 20	10	12	1.2
Light use	20- 40	30	24	7.2
Moderate use	40- 60	50	40	20.0
Heavy use	60- 80	70	18	12.6
Severe use	80-100	90	2	1.8
			Totals 100	42.8

Using the above formula the cow months remaining $= \frac{14}{18} \times 600 = 467$ CM.

Total proper use for the pasture can be obtained by adding cow months used and cow months remaining for a total of 1067 CM.

For intensive management or research studies, where pastures are subdivided for utilization estimates and determination of grazing efficiency, the acreage in each subdivision must also be measured and correlated with grazing capacity in order to calculate needed adjustments in the stocking rate. However, with most utilization checks the use of key areas to indicate the degree of utilization for the whole area is adequate and avoids detailed calculations.

The method, without the photographic guide, has been used in the field by two of the authors for about three years with satisfactory results. The use of the photographic guide will result in more uniform estimates and facilitate its use by less experienced personnel.

For a single key species:

$$\text{Cow months remaining} = \frac{\text{Forage units remaining (7)}}{\text{(Proper use minus current use)}} \times \text{Cow mos. used (600)} = 98 \text{ CM.}$$

$$\frac{\text{Forage units used (43)}}{\text{(Current percentage utilization)}}$$

For several key species:

Species	Forage units available (Percentage composition × Percentage proper use)	Forage units used (Percentage composition × Percentage utilization)	Forage units remaining (Forage units available − Forage units used)
Sideoats grama	40 × 50 = 20	40 × 30 = 12	
Black grama	30 × 40 = 12	30 × 20 = 6	32 — 18 = 14
	Total 32	Total 18	

Test and Analysis of the Grazed-Class Method

To test the accuracy of the method and to study its use on differing types of forage and by personnel with varying experience in estimating utilization by other methods, two inexperienced observers (A and B) and two experienced observers (C and D) estimated utilization by the grazed-class method on two species with differing growth form. The two species were sideoats grama (*Bouteloua curtipendula* (Michx.) Torr.), representing a bunchgrass type growth under desert grassland conditions, and black grama (*B. eriopoda* (Torr.) Torr.), a stoloniferous sodgrass. None of the examiners had any previous experience using the grazed-class method. Estimates were made on a desert grassland site near Sonoita, Arizona.

Before making the estimates, ungrazed fully grown plants were located by toe-pace transect. The plants were clipped to simulate grazing and the clipped forage was placed in individually numbered paper sacks. Three one-hundred-plant transects were clipped for each species, making a total of 600 plants. The clipped plants were then placed into grazed-classes by the examiners using the photographic guides and working independently. After the esti-

mates were made, the remaining part of each plant was clipped to ground line, placed in individually numbered sacks, and stapled with the top sample. The samples were oven dried, individually weighed, and the percentage utilization was calculated by the weight method for each plant. A summary of grazed-class utilization estimates made by the various examiners, as compared to the degree of utilization determined from weight data, is shown in Table 2. The examiners are listed in order of experience in other methods of estimating forage utilization, Examiner A being the least experienced and D the most experienced.

The close correlation between the arithmetic average of 100 weighed values (column 2, Table 2) and the percentage utilization determined by placing the weighed values in grazed-classes (column 3) demonstrates the validity of using the grazed-class method of calculation where 100 estimates are used. An important factor here is that errors of classification are compensating.

To determine the relative accuracy of different sized samples the coefficient of variation of the mean was plotted against sample size, using the data from Replications I for both sideoats and black grama (Figure 2). These curves indicate that errors of less than 5 percent can be expected with 100 estimate samples and errors of less than 10 percent can be expected with samples above 20. Samples below 20 were highly variable and the degree of error increases rapidly with smaller samples. Since, as previously indicated, there was no difference in results between the arithmetic average of 100 weighed samples and the same data placed in grazed-classes, the expected variation is due to sampling and experimental errors rather than to the method procedure of placing estimates in classes.

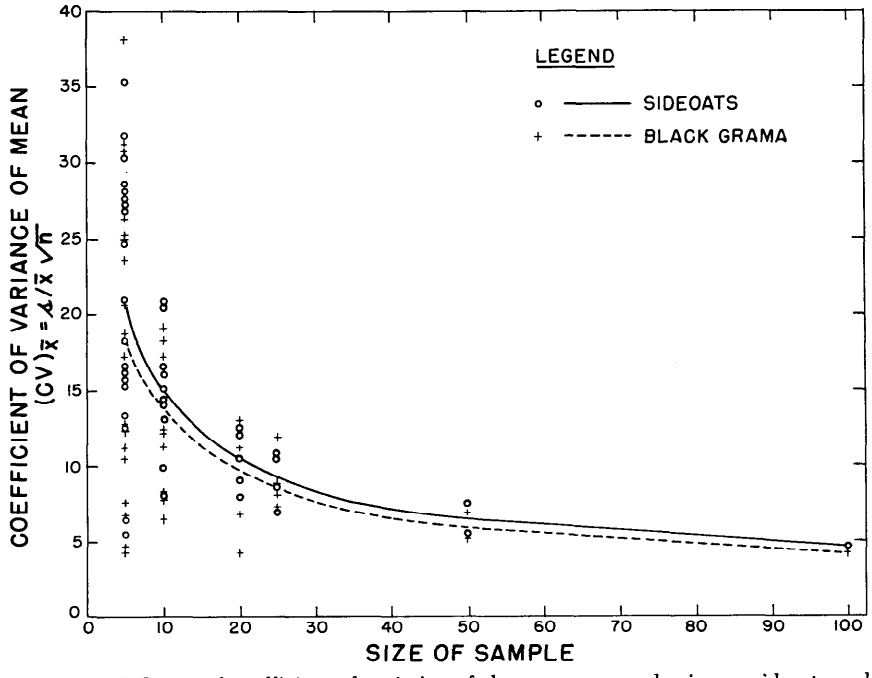

FIGURE 2. Relation of coefficient of variation of the mean to sample size on sideoats and black grama.

Choice of sample size will also depend on variations in pasture conditions; such as variability of grazing, heterogeneity within the type, and other factors. These problems in relation to density estimates are analyzed by Costello and Klipple (1939).

The effect of prior experience in making utilization estimates by other methods is shown in Table 2 by the consistently greater accuracy of the more experienced Examiners C and D.

Statistical analyses of the variation between examiners, weight-checks versus examiners, and between replications for both species are shown in Table 3. These analyses show the effect of experience in using the grazed-class method. Since readings were made on sideoats grama first, the highly significant difference between examiners on the sideoats grama readings followed by no significant difference between examiners on the black grama readings indi-

Table 2. Utilization estimates made by various examiners using the grazed-class method compared to utilization determined from weight data.

Species and replications	Weight method arithmetic average	Estimates of utilization by the grazed-class method				
		Weight check	Examiner A	Examiner B	Examiner C	Examiner D
	(Percent)					
Sideoats grama						
Rep. I	47.5	47.6	33.5	36.1	49.1	47.1
Rep. II	37.5	37.6	32.6	33.3	42.6	43.7
Rep. III	50.9	50.9	39.5	44.5	52.0	47.7
Means	45.3	45.4	35.2	38.0	47.9	46.2
Black grama						
Rep. I	56.1	56.1	40.6	39.3	41.8	48.7
Rep. II	58.7	58.6	43.1	42.3	50.3	52.2
Rep. III	58.5	58.5	47.9	47.1	43.5	48.8
Means	57.8	57.7	43.9	42.9	45.2	49.9

cates that acceptable uniformity can be obtained between examiners after only one or two hours use of the grazed-class method, regardless of prior experience. This uniformity should continue to improve with added experience.

The increased accuracy following experience in the use of the method is confirmed by the variation between replications, which is highly significant in the sideoats grama tests and not significant in the black grama tests. However, part of this difference may have resulted from differences between the growth form of the two plants and variations in degree of clipping.

The analyses of weight-checks versus examiners, emphasizes need for caution in the preparaiton of photographic guides. In developing the photographic guide for this study, sample plants for both species were preclipped at two-inch height intervals, oven-dried and the growth form plotted as height-weight curves. Similar height-weight curves were taken from references by Crafts (1938) and Caird (1945), adjusted to uniform height and averaged with the data from plants clipped in the field. These averages were used to estimate the heights to clip the photo plants used in making the photographic grazed-class guides for the respective species. As a check, the oven-dry weights of the photo plant were plotted with the other curves.

In the case of sideoats grama the curves for the photo guide and photo plant matched quite closely. The use of this guide by the examiners showed a close correlation with the weight-check. In the case of black grama, there was considerable difference between the photo guide and the photo plant curve. The use of this guide resulted in a highly significant difference between the weight-check and estimates by the examiners. (Table 3).

Table 3. Statistical analyses of utilization estimates made on sideoats and black grama by the weight and grazed-class methods.

Source of variation	df	Sideoats grama		Black grama	
		ss	F	ss	F
Examiners:					
Between examiners	3	343.60	19.47**	86.62	3.90
Weight-check vs. examiners	1	29.26	4.98	363.09	49.00**
Between reps	2	201.77	17.16**	51.81	3.50
Error	8	47.00		59.27	

* Significant difference at 5 percent level
** Highly significant difference at 1 percent level

This points up the need for close correlation between the photographic guide and the height-weight curve of the average plant clipped to make the photographs. Since this cannot be determined until after the photographs have been taken and the clipped plant oven dried and weighed, it may mean making several sets of photographs until a close match is obtained.

Another point closely related to this problem is the question of how much the growth form of the guide plant can vary from the plants being estimated in the field. This factor is compensating so considerable variation appears permissible, particularly where larger 50- and 100-estimate samples are taken. Several guides may need to be developed for each key species to match wide year-to-year or site-to-site variations in growth form. Development of guides based on averages of local plants within a given region will reduce the possibility of variation such as might result from using curves developed for broad geographic regions or between states.

The adaptability of a guide for a given situation may be checked by clipping representative plants according to the guide classes, weighing the clipped portions and calculating the various percentages removed. Green weights may be used for quick field checks and oven-dry weights for more accurate data.

The method also tends to reduce errors caused by variability in height growth, one of the major sources of error in height-weight methods. In making estimates of utilization by the grazed-class method, the growth form of the plant is used as the primary guide and visual adjustments for differences in height can easily be made by the examiner.

Another advantage in the use of the method is that, while the estimate of utilization is based on forage removed, each grazed-class shows both the degree of use and the amount of herbage remaining.

The method also facilitates estimation of irregular grazing of plants. Although the guide plants are clipped to a certain height and may not represent the normal pattern of grazing, they do provide a visual picture of the volume by grazed-classes and serve as a guide to the examiner in estimating irregular use of the plant, such as occurs in side-trimming of leaves or partial-grazing of seed stalks. This requires judgment on the part of the examiner but accuracy increases with experience and errors are compensating. Thus the method is largely free from personal bias yet allows for experienced judgment on grazing use of irregularly grazed plants.

The importance of a guide to standardize utilization estimates is indicated by Smith (1944) who analyzed density estimates made by uniformly and intensively

trained examiners. He found that personal bias and inconsistencies of estimates made without benefit of a guide resulted in highly significant variation among men from day to day and even on the same plots at different times of the day. Some individuals tended to remain high estimators and others low estimators but there occurred many exceptions with a given individual showing significant inter- and intra-daily variation. Therefore, the use of a guide facilitates making of uniform estimates by inexperienced ranchers and technicians after relatively little training. However, setting up and checking the adaptability of the guide remains a technical job.

The grazed-class method is adaptable for use in both administration and research. Use of the method on a single dominant key species with relatively few estimates provides the rancher or technician with a simple, fast, moderately accurate method of checking the grazing use of a pasture. On the other hand, larger samples, taken more frequently on more species, provide more accurate, statistically analyzable data for more intensive studies in both administration and research.

Many problems remain to be solved in range utilization. These include studies on the variability of proper use factors of various species under different range conditions and different degrees of use and vigor; the degree of water development and other improvements necessary to obtain uniform grazing; the effects of soil fertility, slope, exposure, shading and other site factors on grazing use; regrowth as a factor in utilization; variations in use at different seasons and by different classes of livestock and game; measurement of proper use on plants with differing growth forms; and rechecks on the validity of the key species and key area concepts. The availability of this fast, statistically sound, reasonably accurate method of measuring utilization provides a useful tool to help solve some of these problems.

Summary

A grazed-class method of estimating range utilization combines the advantages of several systems in use. It is proposed for use in both administrative and research phases of range management.

The method is based on a procedure which classifies grazed plants into six grazed-classes — 0, 10, 30, 50, 70 and 90 percent use. Photographic guides, developed from height-weight curves of average local plants, are used for each key species to guide the examiner in placing grazed plants into the grazed-classes. Representative samples of 20, 25, 50 or 100 plants, located by toe-pace transects, are estimated for each key species to determine the percentage of grazed plants in each grazed-class. Current utilization is calculated by multiplying the average use factor for each grazed-class by the corresponding percentage of grazed plants in each class and totaling the products. Based on this percentage of current use, plus data on the cow months grazed and proper use of the key species, the cow months remaining and the total proper use can be estimated by simple calculations.

The method was tested against the weight-method and was found to be fast, simple, statistically sound and reasonably accurate. Estimates were made on two species, sideoats grama and black grama, representing a bunchgrass and sodgrass type growth. After only a few hours use of the method, statistically satisfactory estimates were made by both experienced and inexperienced examiners.

The use of photographic guides makes possible the estimation of utilization based on forage removed (but also shows herbage remaining) and facilitates judgment of irregular grazing on the plant. Errors are compensating and guides can be easily checked against clipped weights.

The method requires reasonably close correlation between the photographic guide and (1) the height-weight curve of the average plant used to make the guide and (2) the growth form of the plants estimated in the field, but permits considerable variation in height of plants.

The grazed-class method is easily adapted to use by ranchers, technicians or research workers. Many problems in utilization remain to be solved and the grazed-class method offers a tool to help solve these problems.

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