Sideoats Grama as an Indicator of Grazing Intensity and A Method of Determining Its Utilization

WILLIAM J. WALDRIP

Associate Range Scientist,
Texas Agricultural Experiment Station, Seymour, Texas

Highlight

Sideoats grama is a key species for indicating forage use on the Rolling Plains of Texas. A regression equation for field determination of percent utilization of sideoats grama was developed and tested. The method developed, based on measurements of total height and stubble height, is more rapid and accurate than other methods commonly used by technicians.

Judicious stocking to obtain proper use is an essential economic factor in livestock production on rangeland. However, the inherent low productivity of most rangelands necessitates utilization surveys on vast, usually heterogeneous areas. Under these conditions, most methods have been undesirable because of the low degree of accuracy or the time and expense necessary.

Forage use is determined by the impact of grazing on the most abundant palatable plants (Hedrick, 1958). When the ecology of the area is understood, utilization surveys may be simplified by selecting a key species upon which to base proper use. This species must be one that is relatively or potentially abundant, palatable, one that endures moderately close grazing, and one that is an indicator of the entire forage complex.

Sideoats grama (*Bouteloua curtipendula* (Michx.) Torr.) was chosen for the present study because it most closely met the requirements outlined. After determining the reliability of this grass as the key species on the shallow uplands of the Rolling Plains of Texas, a rapid, accurate method for estimating its use by grazing animals was developed.

Experimental Areas and Procedures

Study Locations. — Utilization studies were conducted on the Perryman Ranch in Baylor County (Site A) and the Texas Experimental Ranch in Throckmorton County (Site B) to determine the feasibility of using sideoats grama utilization as an indicator of grazing use. Both sites represent major ecological types in the Rolling Plains. Site A was a level area of shallow, slowly permeable, gravelly clay supporting principally short and midgrasses. Site B was representative of the most common range site on the Texas Experimental Ranch. The topography was gently rolling, and the soil was dark brown, shallow and slowly permeable. This soil type also supported principally short and mid-grasses.

Extreme variation in ecological adaptation, morphological characteristics and chromosome numbers of *B. curtipendula* has been noted by Gould (1959). However, in the Rolling Plains of Texas, the broad-bladed rhizomatous form, *B. curtipendula var. curtipendula,* (Gould and Kapodia, 1964) is the most common and most desirable for forage. Therefore, sampling for this study was limited to this more abundant and desirable type. Preliminary surveys comprising stem counts and height measurements indicated that the following locations adequately

embraced variations in growth form of the species in the Rolling Plains:

1. R. A. Brown Ranch, Throckmorton County
2. Seymour Country Club, Baylor County
3. McGinty Ranch, Dickens County
4. Texas Agricultural Experiment Station, Edwards County

Location 4 was not on the Rolling Plains, but supported a population of the broad-bladed, rhizomatous sideoats grama.

Experimental Procedure. — Two adjacent areas were selected for studies on the Perryman Ranch (Site A) to determine grazing use. These two areas, each one acre in size, were similar except that grazing was excluded for one growing season on one while the other was grazed. One hundred plots, each 1.9 square feet in area, were randomly established in each area. All herbaceous material was clipped at ground level from each plot and separated by species. Each sample was then air dried and weighed to the nearest 0.1 gram for determining utilization. The clippings on this site were made in September, 1959; but since the entire area was subjected to grazing shortly thereafter, additional clippings could not be made.

In September, 1960 and 1961, similar studies were conducted on the Texas Experimental Ranch (Site B).

These studies were for the purpose of determining species composition by weight for the grazed and ungrazed plots in order to evaluate the role of the more abundant species, particularly sideoats grama, as forage providers and as indicators of forage utilization.

The number of randomly selected samples collected from each of the four locations for the height-weight study was determined from the formula $n = \dfrac{4 \, s^2}{L_2}$ (Snedecor, 1956) where n is the number of samples, s is the standard deviation and L is the allowable error of the sample mean. Preliminary studies indicated that the number of plants necessary for an allowable error of no more than 10% of the sample mean

varied from 13 plants at Throckmorton to 20 at Seymour. These numbers gave a probability of 0.95 that the true mean was within 10% of the sample mean.

In two successive years, two hundred plants, in groups of 25 samples each, were selected from the four locations after the first killing frost. Each sample consisted of a 4-inch square segment of sideoats grama sod. The number of culms and the total height to the nearest inch were recorded for each sample.

The samples were removed to the laboratory where soil, roots and foreign matter were carefully removed. Each was then wrapped spirally with string from the base upward and the base was measured to the nearest 0.1 inch with a diameter tape. Each plant then was divided into 1-inch segments which were oven dried at 105°C. for 24 hours and weighed to the nearest mg.

Since stubble height is a direct result of utilization, the measurements of total height, wrapped diameters and numbers of stems were made in order to determine their influence upon stubble height at a given level of use. Coefficients of determination and standard partial regression coefficients indicated that total height was the most reliable single variable for estimating stubble height at a given level of use. The increased accuracy gained from combinations of 3 variables was not sufficient to justify their use.

Regression equations were developed to show the relationship between stubble height and total height at different levels of utilization.

Regression equations were developed for field use for estimating utilization with stubble height and total height as independent variables. These were tested and compared with ocular estimates by experienced technicians to determine the relative efficiency of the regression equations for estimating percent utilization.

Five experienced range technicians estimated utilization on 20 numbered plants clipped at various stubble heights. The numbers were then changed and the estimates repeated in order to determine the ability of experienced personnel to repeat their evaluations. Utilization determinations were also made on the same 20 plants using the regression

equations. Actual utilization was then determined from weights of the clipped and unclipped portions of each plant. Accuracy of the utilization methods was determined by comparison of the various estimates with actual use. Analyses of variance were used to determine significance of mean difference within men and between men using the ocular estimate method.

Results and Discussion

Utilization Studies. — Sideoats grama comprised a major portion of the forage consumed in all of the utilization studies. Names of all herbaceous species clipped on both sites are listed in Table 1.

Total forage utilization of Site A was 24.4% of the total production or 287 lb/acre (Table 2). Sideoats grama utilization was 38.5% or 106 lb/acre.

Clipping studies were conducted for two successive years on Site B. Forage use the first year was 674 lb/acre or 26.7% of the total forage produced. Utilization of sideoats grama was 634 lb/acre or 62.6%.

Total production on Site B was greater in 1961 than in 1960 (Table 2). However, because of increased livestock numbers, forage use was heavier. Total use was 1356 lb/acre or 35% of the total forage production. Sideoats grama utilization was 626 pounds or 51.6%. Ideal grazing conditions brought about by well distributed precipitation evidently increased the palatability of Texas wintergrass and buffalo grass. Curly mesquite grass, which received 60.8% use in 1960, was apparently unused in 1961.

Sideoats grama was consistently selected by livestock in greater quantity than any other major forage species on both sites A and B. Field observations indicated that sideoats grama was utilized by cattle during all months of the year. Consumption of other abundant forage grasses on these sites was greatly influenced by stage of growth or soil moisture relationships.

On the basis of the information obtained from these studies it was concluded that sideoats grama is a key species on the shallow upland sites on the Rolling Plains.

Height-Weight Studies—Individual and Group Relationships:

In the height-weight studies, in-

Table 1. Specific and common names of plants encountered in clipping studies on Sites A and B.

Species	Common Name
Grasses:	
Aristida longiseta Steud.	Red threeawn
Aristida wrightii Nash	Wright threeawn
Bouteloua curtipendula (Michx.) Torr.	Sideoats grama
Bouteloua hirsuta Lag.	Hairy grama
Bouteloua rigidiseta (Steud.) Hitchc.	Texas grama
Buchloe dactyloides (Nutt.) Engelm.	Buffalograss
Eriochloa sericea (Scheele) Munro	Texas cupgrass
Hilaria belangeri (Steud.) Nash	Curlymesquite
Panicum hallii Vasey	Halls panicum
Schedonnardus panniculatus (Nutt.) Trel.	Tumblegrass
Sporobolus asper var. *hookeri* (Trin.) Vasey	Meadow dropseed
Sporobolus cryptandrus (Torr.) A. Gray	Sand dropseed
Stipa leucotricha Trin. and Rupr.	Texas wintergrass
Tridens albescens (Vasey) Woot. and Standl.	White tridens
Tridens muticus (Torr.) Nash	Slim tridens
Tridens pilosus (Buckl.) Hitchc.	Hairy tridens
Forbs:	
Descurainia pinnata (Walter) Britton	Tansy mustard
Evax multicaulis DC.	Rabbit's tobacco
Gutierrezia dracunculoides (DC.) Blake	Annual broomweed
Lappula redowskii (Hornemann) Greene	Flatspine stickseed
Lepidium austrinum Small	Peppergrass
Liatris punctata Hook.	Dotted gayfeather
Plantago rhodosperma Decaisne	Tallowweed
Solanum elaeagnifolium Cavanilles	Silverleaf nightshade
Solanum rostratum Dunal	Buffalobur nightshade

Table 2. Production and utilization from Sites A and B.

Species	Treatment	Pounds per acre 1959A	1960-B	1961-B	Total	Average percent utilization
Sideoats grama	Ungrazed	275	1013	1214	2502	54.6
	Grazed	169	379	588	1136	
Buffalograss	Ungrazed	125	710	1680	2515	
	Grazed	82	899	1200	2181	13.3
Three-awn	Ungrazed	260	187	102	549	
	Grazed	302	107	70	479	12.8
Texas wintergrass	Ungrazed	—	272	490	762	
	Grazed	—	286	302	588	22.8
Curly mesquite	Ungrazed	—	131	228	359	
	Grazed	—	51	238	289	19.5
Other grasses[1]	Ungrazed	289	68	28	385	
	Grazed	151	35	24	210	45.5
Forbs[2]	Ungrazed	228	142	130	500	
	Grazed	189	92	94	372	25.6
Total	Ungrazed	1177	2523	3872	7572	
	Grazed	890	1849	2516	5255	30.6

[1] Includes hairy grama, Texas grama, Hall's panicum, hairy tridens, slim tridens, white tridens, meadow dropseed, sand dropseed, Texas cupgrass and tumblegrass.

[2] Includes annual broomweed, buffalobur, dotted gayfeather, flatspine stickseed, pepper-grass, rabbit's tobacco, silverleaf nightshade, tallowweed and tansy mustard.

dividual sideoats grama plants from the respective sites in each year exhibited considerable variation in the characteristics measured.

The variation in total height ranged from a low of 9 inches at Throckmorton to an extreme of 37 inches at Spur in 1959. The numbers of culms were extremely variable, ranging from none at Throckmorton to 85 at Spur in 1959.

In wrapped basal diameter the range was from 0.36 inches at Spur in 1958 to 1.43 inches at Spur in 1959.

In total weight both the lightest and heaviest samples were found at Spur. The lightest, 1.974 grams, was collected in 1958 and the heaviest, 45.515 grams, in 1959.

The extremes for stubble heights at the 50% level of utilization varied from 1.6 inches at Seymour in 1958 and 1959 and at Throckmorton in 1959 to 5.9 inches at Spur in 1959.

Coefficients of variation indicated that the least variable measurement was stubble height at the 50% utilization level while number of stems was the most variable. In each group the coefficients of variation associated with total height were less than $\frac{1}{3}$ the magnitude of the coefficients for number of stems.

Although the plants varied widely in height, weight, wrapped diameter, number of stems and stubble height at 50% utilization, the general growth form or weight distribution was similar for all plants. Each segment weight became lighter as distance from ground level increased. Thus, there is a similarity in height-weight distribution of sideoats grama, a sod forming grass, and a bunch grass, such as little bluestem, as noted by McArthur (1951).[1] The similarity of growth form among individual plants of the species was also noted by others (National Research Council, 1962).

Variation Among Groups of Plants:

Significant differences among groups from each location for all measured variables were indicated by analyses of variance. Greater variability occurred between groups than within groups for total heights,

[1] McArthur, J. A. B. 1951. *The use of regression equations to determine utilization of little bluestem, Ph.D. dissertation. Agricultural and Mechanical College of Texas, College Station, Texas. Unpublished.*

wrapped diameters, numbers of stems and stubble heights at 50% utilization. Both sites and years affected these variables.

Group means and standard errors for total heights, numbers of stems, wrapped diameters and stubble heights at 50% utilization were calculated. Average heights ranged from 16.72 inches to 31.64 inches around the mean of 24.75 inches. Group means for stem numbers varied from 1.84 to 22.28 about the average of 11.84. Wrapped basal diameters varied by groups from 0.63 inches to 1.08 inches. The average basal diameter for all groups was 0.78 inch. Group means for stubble heights at 50 percent utilization ranged from 2.44 inches to 4.22 inches around the mean of 3.33 inches.

Correlation coefficients between the measured characteristics were determined on the basis of location and years. Coefficients for total height and number of stems were highly variable; however, in seven of the eight groups, they were positive. A slight positive relationship existed between total height and wrapped diameter, although in only one group was it significant. A strong positive relationship was indicated between numbers of stems and wrapped diameters.

Correlation coefficients of total heights, wrapped diameters and numbers of stems with stubble heights at 50% utilization were determined. Total heights and stubble heights at 50% use exhibited a strong positive relationship. No consistent relationship existed between wrapped diameters and stubble heights at 50% use. Four groups exhibited negative correlation coefficients, none significant. All relationships were positive between numbers of stems and stubble heights at 50% use.

In general all correlation coefficients, including multiple correlation coefficients, tended to decrease slightly as utilization was increased. However, all multiple correlation coefficients were positive and significant at the .01 level.

Standard partial regression coefficients were calculated for stubble heights on the three other variables. The coefficent for stubble height on total height was, at every level of use, at least 2.4 times greater than the standard partial regression coefficients of stubble height on wrapped diameter or on number of stems. Therefore, total height is at least 2.4 times more reliable than either wrapped diameter or number of stems for estimating stubble height at any level of utilization.

Estimating Utilization of Sideoats Grama from Regression Equations:

Because of the large areas involved, range forage use must be easily and rapidly measured if it is to have practical application. Since total height was at least 2.4 times better than any of the other variables studied for estimating stubble height at any level of utilization, total height was the only variable used with stubble height in developing regression equations to estimate sideoats grama utilization in the field.

Regression equations were determined to measure relationships existing among all the variables. According to the coefficients of determination in Table 3, the use of all variables permits the most accurate estimate of stubble height. However, the slight increase obtained in the coefficients of determination by the combinations of independent variables over total height alone were not sufficient to justify the increased labor and time involved in applying the equations to range utilization. In Table 3 the independent variables are ranked according to their coefficients of determination.

Equations were plotted representing the relationship between stubble height at 10% increments of utilization and total height (Figure 1). These 9 equations were then combined into the following multiple regression equation with which utilization in percent may be determined from measurements of total height and stubble height:
$$U = 80.10 - 14.86Y + 0.02X^2 + 0.61Y^2,$$
where U = utilization in percent; X = total height; and Y = stubble height.

Standard errors for the regression coefficients used above are:
$14.8600Y + 0.15$; $0.0187X^2 + 0.0006$; $0.6096Y^2 + 0.0119$.

Test of Method:

Twenty 4-inch by 4-inch samples of ungrazed sideoats grama sod were randomly chosen. Each was then given a number, clipped to simulate grazing and the stubble height measured. Five experienced technicians estimated utilization on the 20 samples. After the initial twenty estimates were made by each man, the sample numbers were changed. The five technicians then re-estimated utilization on the twenty samples in order to test repeatability by indi-

Table 3. Coefficients of determination (r^2 or R^2) between stubble height and the variables indicated at different levels of utilization.

Independent Variables	Levels of Utilization in Percent								
	10	20	30	40	50	60	70	80	90
Total height	.562(4)[1]	.607(4)	.526(4)	.487(4)	.413	.376(4)	.359(4)	.299(4)	.327(3)
Wrapped diameter	.018	.013	.009	.002	.004	.001	.0002	.001	.002
Number of stems	.165	.173	.149	.123	.107	.092	.087	.071	.070
Total height and wrapped diameter	.567(3)	.616(2)	.540(2)	.510(2)	.438(2)	.421(2)	.393(2)	.334(2)	.379(2)
Total height and number of stems	.570(2)	.613(3)	.531(3)	.490(3)	.416(3)	.377(3)	.360(3)	.300(3)	.327(3)
Wrapped diameter & number of stems	.187	.206	.188	.169	.160	.173	.146	.135	.140
Total ht., wrapped diameter & number of stems	.593(1)	.643(1)	.569(1)	.533(1)	.464(1)	.454(1)	.415(1)	.360(1)	.381(1)

[1] Rank of method at each level of use.

EQUATIONS

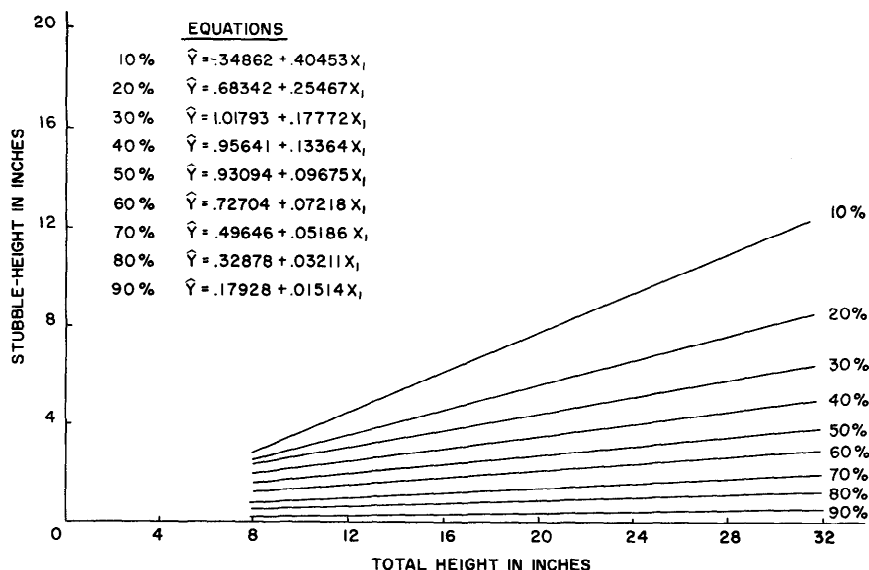|	
10%	$\hat{Y} = -.34862 + .40453X_1$
20%	$\hat{Y} = .68342 + .25467X_1$
30%	$\hat{Y} = 1.01793 + .17772X_1$
40%	$\hat{Y} = .95641 + .13364X_1$
50%	$\hat{Y} = .93094 + .09675X_1$
60%	$\hat{Y} = .72704 + .07218X_1$
70%	$\hat{Y} = .49646 + .05186X_1$
80%	$\hat{Y} = .32878 + .03211X_1$
90%	$\hat{Y} = .17928 + .01514X_1$

FIGURE 1. Regression equations for determining utilization from stubble height (Y) and total height measurements (X).

vidual estimators. The remaining stubble of the 20 samples was then clipped. All clippings were air dried, weighed and utilization percentages computed.

Repeatability of estimate was quite varied both between men and between plants. Only one man exhibited a high level of consistency on each sample. Two of the men overestimated utilization slightly both times, and one underestimated actual use both times. Average estimates exhibited a range of from 34 to 62% around the actual 45% utilization.

A highly significant interaction, men x times, indicated that the estimates of the men were not consistent at different times. Also, a highly significant man x plants interaction indicated that the men were not consistent in their estimates on different plants. These interactions indicated that one man was not able to duplicate another man's estimate to any appreciable extent, nor was the same man able to repeat his estimate on the same or different plants at different times.

In almost every instance the estimate of percent utilization using the regression equation was closer to actual use than the estimate by any of the technicians. The average estimate of all plants, using the regression equation, was 47%. This was nearer the actual 45% utilization than 9 of the other 10 estimates and was as accurate as the nearest estimate of any of the 5 technicians using the

ocular-estimate-by-plant method.

Thus, it may be concluded that the method of determining utilization of sideoats grama by the use of regression equations based on stubble height and total height is far more accurate than ocular estimates, even by trained technicians. In addition, the regression method is simple, rapid and easily applied; and extensive training and practice by the technicians is not a prerequisite to its use.

Method of Field Application:

Estimations in the field, using the equation, requires only an ungrazed area on the same range site as that on which the degree of grazing use is desired. Careful measurement of the total height of 25 random ungrazed samples will give the average total height (X). Average grazed height or stubble height (Y) may be obtained in the same manner. However, care should be exercised by the estimator to insure representative sampling on the grazed area. Distance from water, salt, shade and other factors influencing grazing patterns should be considered. After the X and Y values (total height and stubble height) have been obtained, the percent utilization can be quickly determined from the equation stated above.

Summary

Proper utilization of range forage is of paramount importance in securing maximum sustained yields. In measuring or estimating forage use on any given area, some of the more important species are usually selected from the forage complex. Measurements or observations of these plants, known as key species, are used as indicators of total use on the particular range type.

The palatable, rhizomatous form of sideoats grama is the predominant type on the Rolling Plains of Texas, and was used to develop a rapid, accurate method of measuring utilization.

From data collected on two shallow upland sites on the Rolling Plains of Texas, it was concluded that sideoats grama is a key species for indicating forage use.

Samples, 4 inches by 4 inches in area, of ungrazed sideoats grama sod were collected from four locations in each of 2 years. These samples were prepared for study by removing soil and foreign matter, wrapping with string in cylindrical bundles and recording the total heights, numbers of culms and wrapped basal diameters. The samples were then cut into 1-inch segments and the segments oven dried and weighed to the nearest milligram. The data were then subjected to several statistical tests in order to obtain relationships and variations in growth form.

Individual samples of ungrazed sideoats grama sod exhibited considerable variation in total heights, wrapped diameters, numbers of culms and stubble heights at the 50% level of use. However, the general growth form was similar for all samples. The greatest portion of the weight was concentrated near the base of the plant and weight distribution was similar to that in bunch grasses.

Significant differences for all measured variables (total height,

wrapped diameter, number of stems and stubble height at 50% use) occurred between groups from all locations for both years of data collection.

Correlation coefficients and standard partial regression coefficients indicated that total height is at least 2.4 times more reliable than any other of the measured variables for estimating stubble height at any level of utilization.

Regression equations permitting the determination of stubble height at different levels of use from measurements of all measured variables were developed. However, the increase in accuracy was not sufficient to justify an equation for field determination. Therefore, total height and stubble height were used as independent variables in the regression equation developed for field use. These variables, both easily measured, permit rapid, accurate estimates of the percent utilization of sideoats grama when used in the following equation:

$U = 80.10 - 14.86Y + .02X^2 + .61Y^2$, where U = utilization in percent; X = total height; and Y = stubble height.

The reliability of the equation was tested under field conditions by comparing estimates of use on samples clipped to various stubble heights to simulate grazing. These comparisons indicated that the method of estimating forage use based on measurements of total height and stubble height is more rapid, accurate and reliable than the ocular-estimate method commonly employed by skilled technicians.

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