Establishing Browse Utilization from Twig Diameters

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Abstract

Measurement of twig lengths before and after browsing and measurement of twig diameter after browsing are two techniques to estimate utilization. The two techniques were compared for bitterbrush *(Purshia tridentata)* and cliffrose *(Cowania stansburiana)*. Utilization percentages determined from the two approaches were highly correlated. However, regression equations were not required to estimate utilization from the diameter measurements alone. Correction factors were obtained by subtracting the twig tip diameter of unbrowsed twigs from diameter at the browsed tip and from basal diameter; then dividing the corrected browsed-tip diameter by the corrected basal diameter and multiplying by 100. By using the correction factor, valid estimates of percentage utilization were obtained. The numerical value for twig-tip diameter can be obtained from measuring twig tips of a representative number of unbrowsed twigs. Estimating utilization from twig diameter has two major advantages: (1) accurate estimates of utilization can be reconstructed from postbrowsing measurement alone and (2) making a single annual visit to the rangeland can represent a considerable time saving.

Estimating percentage utilization of selected, key browse species provides important information for sound range and big game management programs. A common management technique of measuring twig lengths before and after browsing was suggested by Nelson (1930) and was later modified by Aldous (1945) and Smith and Urness (1962). It received favor because it was accurate and restricted observer bias (Jensen and Scotter 1977). However, primary disadvantages are that it requires measurement both spring and fall and permanently marking branches of the key browse plants (Basile and Hutchings 1966).

Another method, requiring a single annual visit, predicts percentage utilization of twig lengths or weights from twig diameter measurements. Julander (1937) discounted using diameter measurements because of difficulty in securing them. Basile and Hutchings (1966) and Lyon (1970) concluded that length-diameter and weight-diameter relationships offer promising methods for estimating utilization of shrubs from post-browsing diameter measurements. Ferguson and Marsden (1977) developed equations for estimating overwinter utilization of bitterbrush *(Purshia tridentata)* in southern Idaho.

Our study tested the ability and utility of diameter measurements to predict utilization by mule deer *Odocoileus hemionus)* and field conditions. Examining plants browsed by mule deer represents an important extension of studies where twigs were hand-clipped by researchers to simulate browsing, and is a necessary step to determine reliability of the method for application by range and wildlife managers. The work was supported by Utah Division of Wildlife Resources Federal Aid Project W-105-R.

Methods

Utilization was estimated for bitterbrush and cliffrose *(Cowania stansburiana)* using length of twig-removed and browsed-twig diameter methods. During fall, 1969, near Fillmore, Utah, 4 cliffrose plants were marked on each of 3 exposures: a north facing, ridge top and south facing. On the north facing exposure, 2 branches per plant were selected and permanently marked. On each branch 10 unbranched twigs of current year's growth were individually marked with color-coded wires. The lower branch was between 0.3 and 1.0 m and the upper branch was between 1.0 and

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1.7 m above the ground. The length of each twig from the bud scale scar to the terminal bud was measured to the nearest mm. Basal diameters were measured with a dial-reading caliper to the nearest 0.05 mm just above the bud scale scar (Fig. 1). The same procedure was followed for shrubs on the ridge top and south exposures except that 5 twigs instead of 10 were marked and measured on each branch. Residual lengths of marked twigs were measured in spring of 1970 as were twig diameters at the browsed tip. If twigs were unbrowsed the tip diameter at the first measurable internode below the terminal bud was recorded.

Ten bitterbrush plants were marked for observation on a south-facing exposure in Blacksmith Fork Canyon near Hyrum, Utah. Two branches per plant and 10 twigs per branch were marked for measurement. Growth form and lower stature of bitterbrush precluded stratifying branches into 2 height zones similar to cliffrose. Twig lengths and diameter were measured as described for cliffrose except the basal diameters were measured twice. The second measured was at right angles to the first and at the same distance above the bud scale scar.

Percentage utilization (U) was determined in three ways:

1) $$U = 100 \frac{L_f - L_s}{L_f}$$

where L_f is the mean length of all measured twigs in the fall and L_s is the mean residual length of all twigs in the spring, unbrowsed twigs included.

2) $$U = 100 \frac{(D_p - D_t)}{D_b - D_t}$$

where D_p is the twig diameter at the point of browsing, D_t is that diameter at the twig tip, and D_b is the basal diameter. The concept of this formula will be discussed later.

3) $$U = 100 \frac{L_u}{L_t}$$

where L_u is the predicted length of browsed twig portions and L_t is the predicted length of current growth twigs in the fall. Predicted lengths were obtained from regression equations.

Results

Mean percentage utilization, calculated directly from diameters and from twig length differences, differed by small amounts. Cliffrose was utilized 86±4.4% and 72±3.7% and bitterbrush was utilized 64±4.5% and 58±3.7% when calculated by the respective techniques. The discrepancies were only 4% and 6% and confidence intervals overlapped in both cases. Some twigs were completely browsed and could not be measured after browsing which may have contributed to the discrepancies. For example, 18 of the 160 cliffrose twigs were browsed flush with or beyond the bud scale scars so that neither basal diameters nor diameters at the browsed tip could be measured after browsing. Measurement of the browsed tip of 2-year-old wood, which was not done, may have lessened the disparities. Percentage utilization calculated by substituting mean diameters into prediction equations were:

$$U = \frac{59.0 + 99.4(157.7)}{-104.5 + 122.8\,(195.8)} \times 100 = 73.6 \pm 3.5\%$$

for cliffrose and for bitterbrush

$$U = \frac{125.7 + 134.8(147.2)}{-144.0 + 151.1(178.1)} \times 100 = 73.6 \pm 3.5\%$$

at the 95% confidence level.

The parenthesized values are mean diameters. Those in the numerators are diameters at the browsed tip and those in the denominators are basal diameters of twigs. We must stress, at this point, that regression equations in the numerators are calculated from measured lengths of twigs removed—something that cannot be obtained from spring measurements alone. The equations in the denominator can be obtained in the spring by measuring lengths and basal diameters of unbrowsed twigs. The predicted utilization closely agreed with percentages computed directly from lengths and diameters for cliffrose, but differed considerably for bitterbrush.

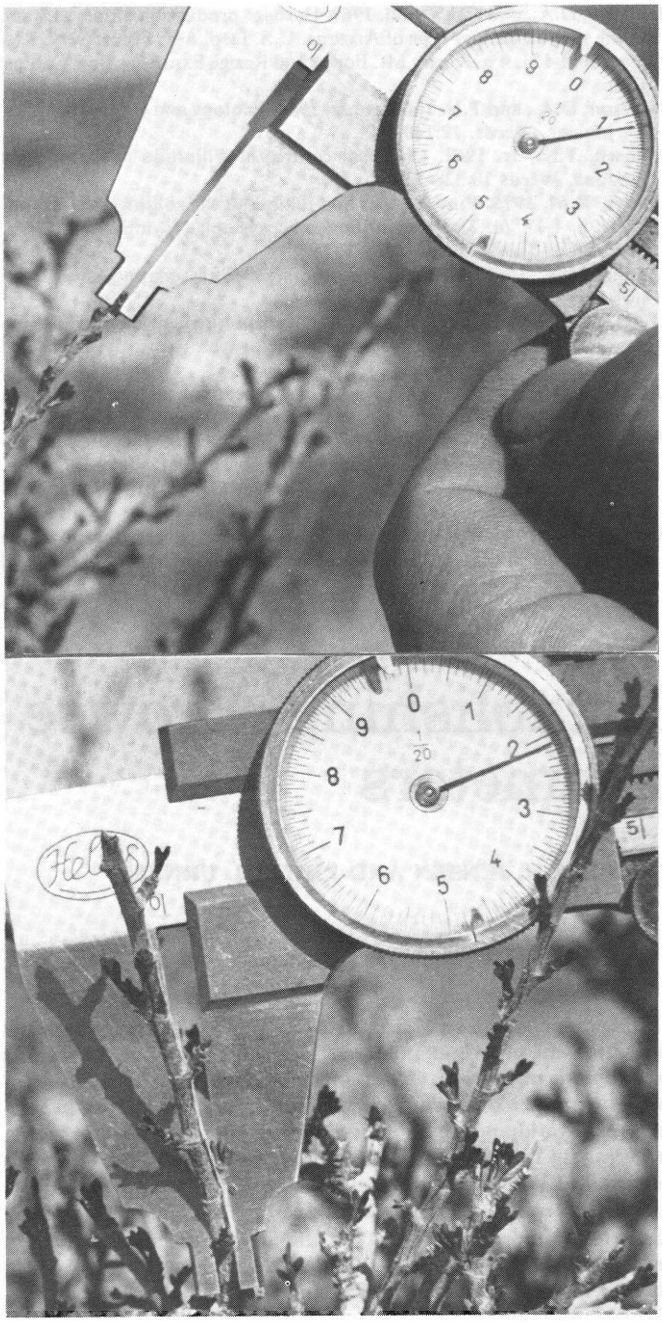

Fig. 1. *Measurement of some unbrowsed twig tip diameters with a dial-reading caliper is necessary (above). Measurement of browsed twig tip diameters and basal diameters of twigs is also required (below).*

Correlation coefficients relating total lengths and basal diameters for 20 or more cliffrose twigs ranged from 0.48 to 0.90 among positions and site factors tested (Table 1) and all but one were statistically significant. Correlation coefficients relating lengths of twigs consumed and diameters at the browsed-twig tips were lower than those for the original measurements of total twig length and basal diameter on the same twigs (Table 2), partly due to the loss of some twigs to browsing and subsequent reduction in degrees of freedom. The correlation of length with diameter of bitterbrush was highly significant (R=0.84 before browsing and 0.72 after

Table 1. Correlation coefficients between total lengths and basal diameters of cliffrose twigs by aspects and positions on plants.

Position	Aspect			
	North	Ridge	South	Combined
Lower branches	.663***	.747***	.839***	.651***
Upper branches	.587***	.902***	.478	.684***
Combined lower and upper	.633**	.841***	.684***	.699**

** Significant, $P \leq 0.01$.
*** Significant, $P \leq 0.001$

Table 2. Correlation coefficients between twig lengths consumed and diameters at the browsed twig tips by aspects and positions on cliffrose plants.

Position	Aspect			
	North	Ridge	South	Combined
Lower branches	.371**	.097	.737**	.232***
Upper branches	.207	.647**	.191	.446***
Combined lower and upper	.357**	.607***	.332*	.345***

* Significant, $P \leq 0.05$.
** Significant, $P \leq 0.01$.
*** Significant, $P \leq 0.001$.

browsing). Coefficients for 20 twigs on individual bitterbrush plants ranged from 0.61 to 0.92 before browsing and from 0.58 to 0.89 after browsing. Less than 30 twigs were required to provide significant correlations at the 95% confidence level.

There was little difference in the two basal diameter measurements on each bitterbrush twig. The greatest difference observed was .07 mm and most measurements varied less than .03 mm. Consequently, the first measurement was used for data analysis.

Discussion

The prediction of weights or lengths from diameter has been the objective of studies in the past. Although knowledge of those relationships must be understood, valid estimates of utilization for bitterbrush and cliffrose can be made from diameter data alone. There are two major points which must be considered. First the regression line does not pass through the point of origin (Fig. 2). In plotting the length (y) on diameter (x), the diameter has some positive value when length equals 0. Bud primordia develop isometrically until twig elongation ensues. Thereafter, the diameter of the terminal bud remains constant, that is, the elongating twig has a truncated apex. The value of (x) when $(y) = 0$ estimates the diameter of the truncated apex, in this case slightly less than 1 mm for both cliffrose and bitterbrush. Second, in consequence of the first point, the twig tip diameter must be subtracted from both the browsed tip and basal diameters:

$$U = 100 \left(\frac{E_p - D_t}{D_b - D_t} \right)$$

where symbols are those in number 2 procedure for determining utilization. Diameter at the browsed tip provides a direct estimate of the amount removed, not the amount remaining on each twig.

A hypothetical example will help to elucidate the need to subtract the twig tip diameter from both numerator and denominator in direct computations. Consider the following: The length of a twig was 100 mm before browsing and 50 mm was browsed. Basal diameter was 2.0 mm and at the browsed tip it was 1.5 mm. The twig tip diameter before browsing was 1.0 mm. Percentage utilization by diameter difference, without subtracting the twig tip diameter from the other two measurements is 1.5 mm divided by 2 mm times 100 equals 75%. When the tip diameter is subtracted (1.5 mm–1.0 mm) divided by (2.0 mm–1.0 mm) times 100 equals 50% as it should be by length utilized. Failure to subtract the tip diameter biases utilization values upward by direct computation methods and that bias is exaggerated for short twigs.

Basile and Hutchings (1966) demonstrated that diameter was a valid predictor of bitterbrush twig length using linear equations. Although significant site differences were observed, these were of little practical importance. While the technique had not been field tested, it provided high statistical confidence.

Differences were detected by Lyon (1970) in regression of length or weight on diameter of serviceberry *(Amelanchier alnifolia)* twigs related to site, plant, size, location on the plant, and other attributes, but the differences were small. Telfer (1969) developed natural logarithmic regression equations to predict weights from diameters of twigs for 38 northeastern browse species, the assumption of linearity being valid in small diameter ranges. Regression equations were developed by Peek et al. (1971) for 9 woody species in Minnesota and fewer than 50 twigs were needed to estimate within 20% of the true coefficient at the 95% confidence level.

Since we obtained results for the entire winter period and fairly heavy utilization, the question arises: Do these relationships hold

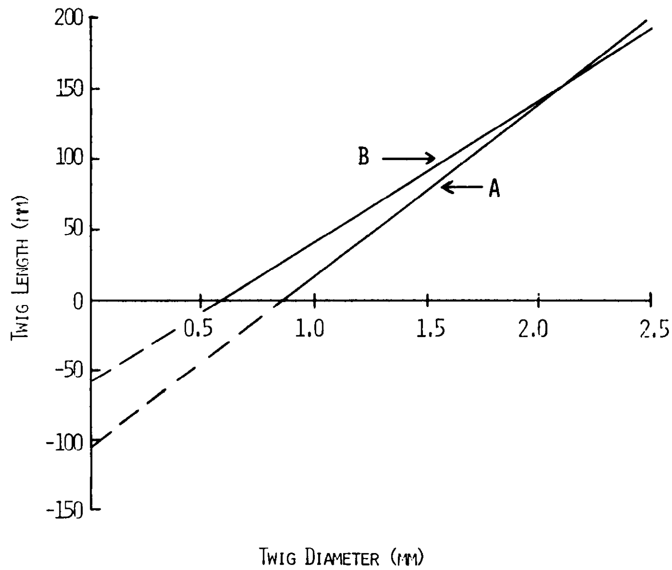

Fig. 2. *Linear regression lines for (A) total twig length on basal diameter of cliffrose (Y = −104.5 + 122.8X) and (B) length of the twig utilized on diameter at the browsed tip (Y = −59.0 + 99.4X).*

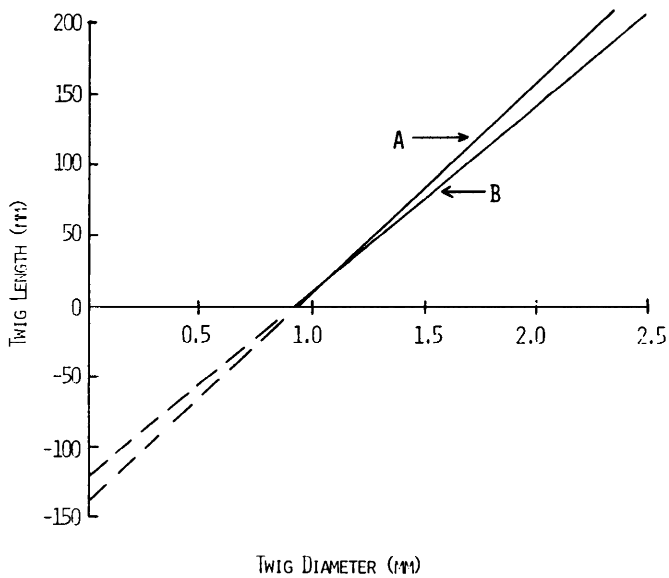

Fig. 3. *Linear regression lines for (A) total twig length on basal diameter of bitterbrush (Y = −144.0 + 151.1X) and (B) length of the twig utilized on diameter at the browsed tip (Y = −125.7 + 134.8X).*

for other levels of utilization? As indicated by work of others, and based upon a valid assumption of linearity; utilization determined from lengths or diameters should be close for all levels of utilization. We plan to examine different levels of use and other Intermountain browse species in the future.

In conclusion, regression equations are not necessary to establish utilization percentages from diameter measurements, but they are necessary to estimate weights or lengths removed. Length and diameter methods may yield slight differences in estimates of percentage utilization, but they are sufficiently close so either adequately estimates the same mean. An important advantage of diameter measurements is that accurate enumeration data can be obtained on areas after browsing animals have left the range, freeing the manager from time-consuming fall measurements. Further, precise utilization estimates can be obtained without prior knowledge of twig length. Measurements in the spring should follow a procedure that eliminates personal bias in selection of twigs and represents all size classes. This appears to be more important than securing a large number of twigs or plants.

Twig tip diameter measurements are essential and can be obtained from regression equations, but these data are easily obtained by measuring twig tips of a representative sample. From our data, as few as 20 twig tips provided means with 5% of the true mean at the 95% confidence level. Perhaps 30 or more should be measured since little effort is involved.

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