Twig Diameter-Length-Weight Relations Of Bitterbrush[1]

JOSEPH V. BASILE and SELAR S. HUTCHINGS

Associate Plant Ecologist and Principal Plant Ecologist, Intermountain Forest and Range Experiment Station, Forest Service, U.S.D.A., Bozeman, Montana, and Ogden, Utah, respectively.

Highlight

Relations between bitterbrush twig diameters and their lengths and weights are sufficiently consistent to enable wildlife technicians to estimate browse utilization solely from postbrowsing measurements of the diameters and lengths or weights of the remaining portion of twigs.

Wildlife technicians often determine browse utilization by measuring length of selected current year's twigs before and after browsing. The difference in lengths represents utilization, usually expressed in percent. Knowledge of the relations between twig diameters and their lengths and weights may provide a means of estimating utilization solely from postbrowsing measurements, and may also permit expressing utilization in terms of either length or weight of twigs.

Two hypotheses were proposed for testing: (1) both lengths and weights are highly correlated with twig diameters; and (2) a single regression equation may yield reliable estimates of twig lengths or weights for a given species. If these hypotheses are valid, measurement of twig diameter after browsing provides an index of twig length and weight before browsing; then, from a measurement of either length or weight of the remaining portion of the twig, percent utilization can be computed.

We chose bitterbrush (*Purshia tridentata* (Pursh) D.C.) as the species to use in testing these hypotheses because this shrub is relished by most species of big game and livestock, it is widespread in occurrence, and it is important in the winter diet of deer in our area. Bitterbrush utilization is the criterion most often used by game managers in southern Idaho to indicate whether deer populations are in balance with their forage supplies.

Our sampling was confined to two contiguous sites in a stand of mature bitterbrush 18 miles east of Boise, Idaho. Site 1 faced generally northeast on a slope of approximately 40%. Site 2 was on a southeast-facing alluvial fan of about 5 to 20% slope. Soils on both sites have been derived from granitic rocks. Precipitation averages 15 inches per year. Elevation is approximately 3,100 feet.

Methods

During plant dormancy we sampled current-year twigs from 20 mature shrubs on each site. Sampling was confined to unbranched, unbrowsed terminal and lateral twigs at least 1 inch long.

Each shrub was sampled by quarters—upper north, lower north, upper south, and lower south. Twelve twigs were selected from each quarter by visually dividing the quarter into three equal portions and choosing four twigs from each portion. Twig selection was subjective in that a wide range of twig sizes was sought in each portion of the shrub.

Twigs were removed from the shrubs, tagged, and taken to the laboratory for measurement. Lengths were measured to the nearest 0.1 inch, including the terminal buds. Diameters were measured with a dial gage (Fig. 1) to the nearest 0.001 inch at a point 0.5 inch from the twig base. If a bud occurred at this point, it was removed to facilitate measurement; if node swelling occurred, the twig diameter was measured immediately above or below the swelling, whichever was nearer the 0.5-inch mark. Cross sections of most twigs were somewhat elliptical; hence, an average of the minimum

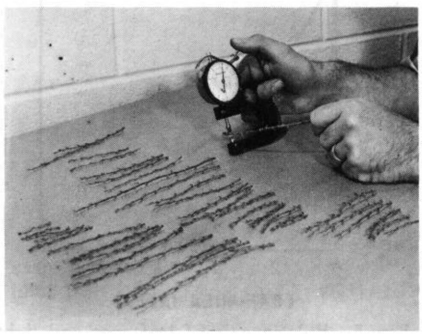

Fig. 1. Dial gage used to measure diameter of bitterbrush twigs.

[1] *Tests herein reported were part of a cooperative study by the Intermountain Forest and Range Experiment Station and the Idaho Fish and Game Department through Federal Aid to Wildlife Restoration Project W-111-R.*

and maximum diameters was used for all computations. Twigs were oven-dried at 70 C for 24 hours and then individually weighed to the nearest 0.01 g.

Twig measurements from all shrubs were appropriately grouped to yield one regression equation for each quarter for each site and for both sites combined. Coefficients were computed for the regressions of: length on diameter, weight on diameter, weight on length, and weight on diameter + length.

Results

Results obtained in this study are unusual in that most differences in regression coefficients were statistically significant but were too small to have practical importance. This high precision reflects the intensive sampling; 12 twigs from each quarter of 20 shrubs provided a sample of 960 twigs for each site.

Regression coefficients were similar for the two upper quarters of the shrubs and also for the two lower quarters. Because of these similarities, data for quarters were combined to compare twigs on the upper versus lower halves and the north versus south halves.

From a practical viewpoint the coefficients for the north and south halves were similar, two "significant" differences notwithstanding (Table 1). However, some differences between vertical segments of shrubs were great enough to be important; twigs on the lower halves were longer and more slender than those on the upper halves. Although such differences might dictate stratification of sampling, they do not rule out the possibility of a single prediction equation. From this viewpoint, the differences between sites appear to be more critical, especially for length and diameter (Table 1). This is discussed later.

The above considerations led to analyses combining data from all shrub segments to obtain a more generalized prediction formula and to evaluate the influence of site on twig conformation (Table 2).

Length-Diameter and Weight-Diameter Relations. — Regressions on diameter accounted for approximately 50% and 80% of the variation in length and weight respectively. Fiducial limits (P.05) for estimating length and weight from the diameter of a randomly selected individual twig were within approximately 50% and 55% of their respective means. However, fiducial limits for a stratified random sample of 30 twigs (Fig. 2 and 3) indicate that the mean length and mean weight probably can be estimated within approximately 10% of their respective actual means. The variation in twig weight (0.04 to 1.14 g) was about twice the variation in twig length (1.0 to 12.8 inches); coefficients of variation were 39 and 62% respectively. Although weight varied more than length it was more closely related to diameter, with the net effect that the residual errors around the regression lines were about equal for weight and length. Therefore, mean twig weight and mean twig length can be estimated with approximately the same precision with equal sized samples.

Differences between length-di-

Table 2. Regression and correlation coefficients for length (L), weight (W), and diameter (D) of bitterbrush twigs based on combined samples of all portions of plants.

Attributes					
Y	X_1	X_2	Site	Regr. coef.	Cor. coef.[1]
L	D	—	1	103.90 **	0.74
			2	79.86	.72
			1+2	89.83	.72
W	D	—	1	6.99 *	.88
			2	7.42	.90
			1+2	7.27	.89
W	L	—	1	.05 **	.89
			2	.06	.85
			1+2	.06	.86
W	D	L	1	b_1 3.87; b_2 .03 **	.95
			2	b_1 4.87; b_2 .03	.95
			1+2	b_1 4.57; b_2 .03	.95

* Differences between regression coefficients on sites 1 and 2 significant at the 5% probability level.

** Differences between regression coefficients on sites 1 and 2 significant at the 1% probability level.

[1] All correlation coefficients are significant at the 1% probability level.

Table 1. Regression coefficients for length-weight-diameter relations of bitterbrush twigs.

		Shrub Segments					
Relation	Site	Upper	vs.	Lower	North	vs.	South
Length-diameter	1	95.65	**	126.59	104.08	n. s.	103.67
		**		**	**		**
	2	78.06	**	104.88	80.82	n. s.	78.98
Weight-diameter	1	6.85	**	7.54	7.05	n. s.	6.92
		**		n. s.	**		n. s.
	2	7.83	n. s.	7.46	7.67	*	7.18
Weight-length	1	0.06	**	0.05	0.05	n. s.	0.05
		**		**	**		**
	2	0.07	**	0.05	0.07	*	0.06

* Differences between shrub segments or between sites significant at the 5% probability level.

** Differences between shrub segments or between sites significant at the 1% probability level.

n. s. Differences not significant at the 5% probability level.

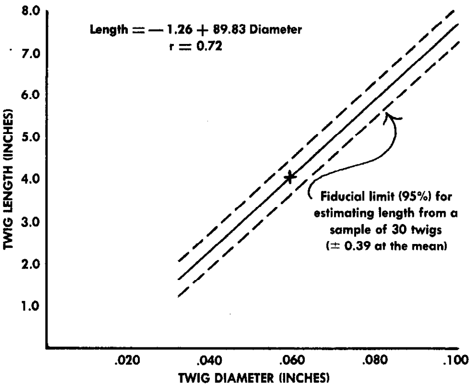

Fig. 2. Relation of twig length to twig diameter on bitterbrush.

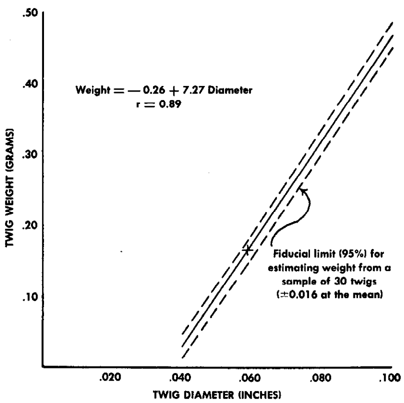

Fig. 3. Relation of twig weight to twig diameter on bitterbrush shrubs.

ameter relations for north and south halves of shrubs were not significant (P.05) on either site, but differences between upper and lower halves were highly significant (P.01) on both sites (Table 1). Twigs of a given diameter usually were slightly longer on the lower halves of shrubs. The relation of length to diameter also differed between sites. Regression coefficients for each canopy segment and for entire shrubs on site 1 differed significantly (P.01) from their counterparts on site 2.

Unlike length-diameter relations, weight-diameter relations sometimes differed with either the radial or the vertical positions of twigs on the shrubs (Table 1). Whereas the vertical position affected the weight-diameter relation on site 1, the radial position affected it on site 2. Twigs of a given diameter were slightly heavier on the lower than on the upper portions on site 1, and slightly heavier on the north than on the south portions on site 2.

Regression coefficients for entire shrubs differed significantly (P.05) between sites (Table 2). Thus the relations between weight and diameter differed between sites as well as between twig positions. However, these between-site and within-site differences, though statistically significant, have no practical significance because the regression lines and coefficients are extremely close (Fig. 4 and Table 1). The use of a stratified sample and of the prediction equation for entire shrubs would practically cancel these small differences.

Weight-Length Relations.—Approximately three-fourths of the variation in twig weights were accounted for by regression with length. The regression equation for weight-length relations for both sites combined was Weight = −0.063 + 0.057 Length, and the correlation, r = .86. Mean weight may be estimated within approximately 11% of the actual mean with samples of 30 twigs. For this size of sample, fiducial limits (P.05) were ± 0.019 gram (rounded to 3 places) both at the mean length and at a 3.0-inch departure from mean length. Fiducial limits for a weight estimate from the length of an individual twig were ± 0.10, or about ± 62% of the mean.

Weight-length relations were also affected by twig position (Table 1). On both sites, twigs of a given length were heavier on the upper part of the shrub than twigs of the same length on the lower half. The regression coefficient for the north halves of shrubs was not significantly different from that for the south halves on site 1, but a difference (P.05) did occur on site 2, where twigs were heavier on the north than on the south side.

Highly significant differences (P.01) between sites also occurred among regression coefficients of the entire shrub canopies. Thus weight-length relations differed between sites as well as with positions of twigs within sites. However, as with weight-diameter relations, these statistically significant differences have little practical importance except perhaps at the very extremes of twig diameters.

Weight-Diameter-Length Relations.—The multiple regression

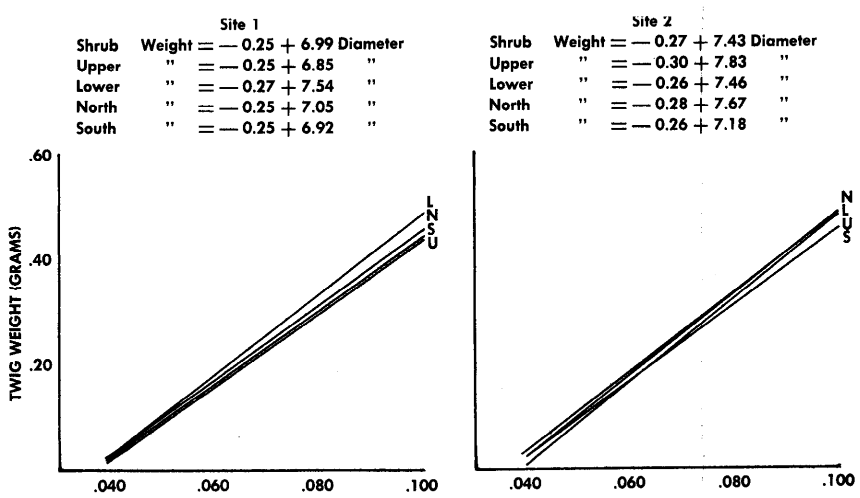

Fig. 4. Relation of twig weight to twig diameter on bitterbrush shrubs as affected by site and by twig position.

of weight on diameter plus length of bitterbrush twigs accounts for 90% of the variation in twig weight. The regression formula for both sites combined was Weight = -0.22 + 4.56 Diameter + .0301 Length. This relation is primarily of academic interest because length of twigs cannot be measured in postbrowsing samples if the twigs are grazed. Hence the relationship cannot be used to estimate twig utilization. However, it can be used to estimate twig production from measurements of twig diameter and length on areas where clipping is undesirable.

On both sites, tests between the multiple regression equations for the four portions of the shrub revealed significant differences due to twig position. Between-site differences were highly significant (P.01). Although the differences were statistically significant they were not great enough to have practical importance. Prediction values of weight obtained from the regression equations are extremely close for twigs within the range of diameters and lengths encountered in the study. A sample of 100 twigs should give reliable estimates of twig weight.

Discussion

The relations of weight to length and to diameter + length provide a basis for developing a method for estimating twig production on areas where clipping is undesirable. However, a concomitant estimate of twig numbers per shrub or per unit area would be needed before these relations would have much practical value.

The length-diameter and weight-diameter relations offer a promising method for estimating bitterbrush use on both a length and weight basis solely from postbrowsing measurements. A measurement of twig diameter after browsing provides an estimate of total length and of total weight before browsing. The length of the portion of twig remaining after browsing can be measured and the percentage utilization can be computed as follows:

$$P = 100 \left(\frac{T - R}{T}\right)$$

where P is the percentage utilization by length, T the total length of twig computed by regression, and R the length of the remaining portion.

To estimate utilization by weight, the portion of twig remaining after browsing can be clipped and weighed and utilization computed by substituting weight for length in the above formula.

Important within-site and between-site differences in regression of either length or weight with diameter would not handicap estimates of utilization. Where these differences are due to twig position on the shrub, sampling each canopy segment at equal intensity would permit use of the prediction equation for entire shrubs. This procedure eliminates the need for tallying data by canopy segments and for use of more than one prediction equation.

Similarly, significant between-site differences need not be as forbidding as they may seem. Estimates of utilization are usually confined to the same few key areas year after year. Unless length-diameter and weight-diameter relations differ significantly from year to year—a variable not tested—a prediction equation need be computed only once for a given key area.

Future savings should more than compensate for the cost of determining the equation. Estimating utilization solely from postbrowsing measurements eliminates the costs of transportation and manpower required for making prebrowsing measurements, the need for tagging twigs for subsequent identification, and the possibility of missing data resulting from lost tags and from lost or undecipherable prebrowsing records.

The proposed method has not been field-tested. However, the accuracy with which means may be estimated from small samples (30 twigs) lends considerable confidence that the method is practical. The same concepts embodied in this method should be applicable to other browse species and to other areas.

Summary

We measured 12 twigs from each quarter segment of 20 bitterbrush shrubs on each of 2 sites. Coefficients were computed for regressions of length on diameter, weight on diameter, weight on length, and weight on diameter + length. Data were grouped to evaluate differences in regression attributable to site and to position of twigs on the shrubs.

Twig weight was highly correlated with length (r = .86) and with diameter + length (r = .95). Both of these relations were affected by twig position on the shrub and by sites, but the differences were too small to have practical importance. Both relations provide a basis for developing a method for estimating twig production on areas where clipping is undesirable.

The length-diameter and weight-diameter relations offer considerable promise for estimating utilization on both a length and weight basis solely from postbrowsing measurements. A diameter measurement after browsing provides an index of total twig length and weight before browsing. The remaining portion of the twig can be clipped and weighed and its length measured and the percentage of utilization can be easily computed.

The highly precise sampling rendered small differences between shrub segments statis-

tically significant, but these differences were too small to have practical importance. A stratified sample would permit use of a single prediction equation based on the entire shrub. Mean length and mean weight may be estimated within 10% of the actual mean with a stratified random sample of 30 twigs.

A separate prediction equation may be necessary for each site. However, unless length-diameter and weight-diameter relations vary with year—a variable not tested—a prediction equation need be developed only once for a site.