

USING TWIG DIAMETERS TO ESTIMATE BROWSE
UTILIZATION ON THREE SHRUB SPECIES IN SOUTHEASTERN MONTANA

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ABSTRACT: Browse utilization estimates based on twig length and twig weight were compared for skunkbush sumac, wax currant, and chokecherry. Linear regression analysis was valid for twig length data; twig weight equations are nonlinear. Estimates of twig weight are more accurate. Problems encountered during development of a utilization model are discussed.

INTRODUCTION

One important aspect of managing large herbivore populations in the United States is the ability to estimate utilization of forage species. As development continues to crowd wildlife species, managing herbivore populations to maintain balance in the ecosystem has become a significant issue. Just as livestock managers should maintain proper use in pastures, game managers should strive to maintain game populations at levels that do not abuse the forage resources. Thus, managers need fast and efficient methods of estimating forage abundance and utilization.

Data on both the amount of forage available and the amount removed are needed to estimate utilization. Techniques have been developed whereby both of these parameters can be estimated from data collected in the spring after browsing has occurred. Relationships of twig diameter to weight and length have been developed for a number of shrub species (Telfer 1969; Lyon 1970; Peek and others 1971). Twig diameter-length and diameter-weight relationships have been shown to vary statistically among sites, shrub species, individual plants, and location on the shrub (Basile and Hutchings 1966; Lyon 1970; Peek and others 1971; Jensen and Urness 1981). However, variations among plants, location on the shrub, and to some extent site differences are of little practical value for estimating utilization (Basile and Hutchings 1966; Lyon 1970). Jensen and Urness (1981) showed that utilization on bitterbrush (Purshia tridentata) and cliffrose (Cowania stansburiana) could be estimated by a series of twig diameter measurements alone. Provenza and Urness (1981) demonstrated that branch and twig diameters could be used to estimate utilization on

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blackbrush (Coleogyne ramosissima) more accurately than measurements taken before and after browsing. Estimates of utilization based on twig diameter measurements can reduce the number of field trips necessary, and accurate estimates of utilization can be made after browsing has occurred (Jensen and Urness 1981).

The objectives of this study were: (1) to develop models from which estimates of utilization of three shrub species based on twig diameter-length and twig diameter-weight relationships could be made, and (2) to compare browse utilization estimates based on twig length with estimates based on twig weight.

METHODS

This study was conducted about 6 km north of Decker, MT, during the fall of 1984 and spring of 1985. Three shrub species, skunkbush sumac (Rhus trilobata), wax currant (Ribes cereum), and chokecherry (Prunus virginiana), were selected for study. Ten shrubs of each species were identified, and 10 twigs on each shrub were selected and marked for sampling. Twigs were selected randomly, but also to represent the full range of current year's growth. Diameters of five twigs on each shrub were measured at the budscale scar and at a point between the budscale scar and terminal bud. Values were recorded to the nearest 0.1 mm. The length from each of the diameter measurements to terminal bud of the twig was also measured. On the other five twigs, twig diameter was measured at the budscale scar and at a point between the budscale scar and the terminal bud. The twig was then clipped at both measurement points, oven-dried at 60 °C for 3 days, and weighed. These measurements provided 100 data points from which to develop the regression equations to predict twig length and twig weight for each species.

Regression models of the form $Y = a + bX$ (where Y = twig length and X = twig diameter) were developed for twig diameter-length relationships using SPSS New Regression (Hull and Nie 1981). Twig diameter-weight relationships were estimated using the SPSS nonlinear regression subprogram (Robinson 1984) for the model $Y = aX^b$ (where Y = twig weight and X = twig diameter). Residuals were analyzed using SPSS New Regression.

Herbivore utilization was examined in the spring on 35 skunkbush sumac, 13 wax currant, and 18

chokecherry plants. On each shrub, a small number of twigs on one branch were selected randomly. Diameters of browsed twigs were measured at the budscale scar and browse point with calipers, and total number of browsed twigs were counted. Utilization estimates were determined from mean diameters by plant species.

RESULTS AND DISCUSSION

Utilization Estimates

Examination of twig diameter-twig length data indicated that linear regression analyses (fig. 1) were appropriate for the three shrub species. The regression fits for twig diameter-length relationships from this study were similar to those reported for bitterbrush (Basile and Hutchings 1966) and bitterbrush and cliffrose (Jensen and Urness 1981), but less precise than those Lyon (1970) reported for serviceberry (*Amelanchier alnifolia*). Previous browsing activity, plant vigor, and age contributed to the variation in twig diameter-length data for chokecherry in this study, especially at the larger twig diameters.

The relationships between twig diameter and twig weights for all three species were nonlinear (fig. 2). The equations developed to predict twig weights for skunkbush sumac and wax currant were very similar (table 1). These two species exhibited similar patterns of twig growth. The nonlinear regression equations for twig diameter-weight relationships for all three species had substantially higher regression fits than did linear estimates of twig diameter-weight relationships. Ruyle and others (1983) and Telfer (1969) reported nonlinear equations for twig diameter-weight relationships. Peek and others (1971) reported high correlation coefficients for twig diameter-weight relationships for most species, and Lyon (1970) indicated that the nonlinear relationship (log transformation) between twig diameter and twig weight did not result in any improvement over the linear model.

Estimates of percent utilization based on twig weights were 24, 41, and 52 percent less than estimates based on twig lengths for skunkbush sumac, chokecherry, and wax currant, respectively (table 2). These differences result from the curvilinear relationships between twig weight and twig diameter. The longer and larger twigs had a greater portion of the total weight in the proximal portions of the twig. Browsing at the end of a twig could result in substantial removal of twig length with less proportional removal of twig weight. Therefore, estimates of twig weight are a more accurate index of utilization. Provenza and Urness (1981) also reported less utilization of browse when twig or branch weight estimates were used, compared to twig or branch length estimates, but attributed the difference to inclusion of leaves in weight estimates. These relative differences in estimates of percent utilization are probably unimportant for species such as wax currant; but, for browse species that show greater utilization, these differences become more important to managers.

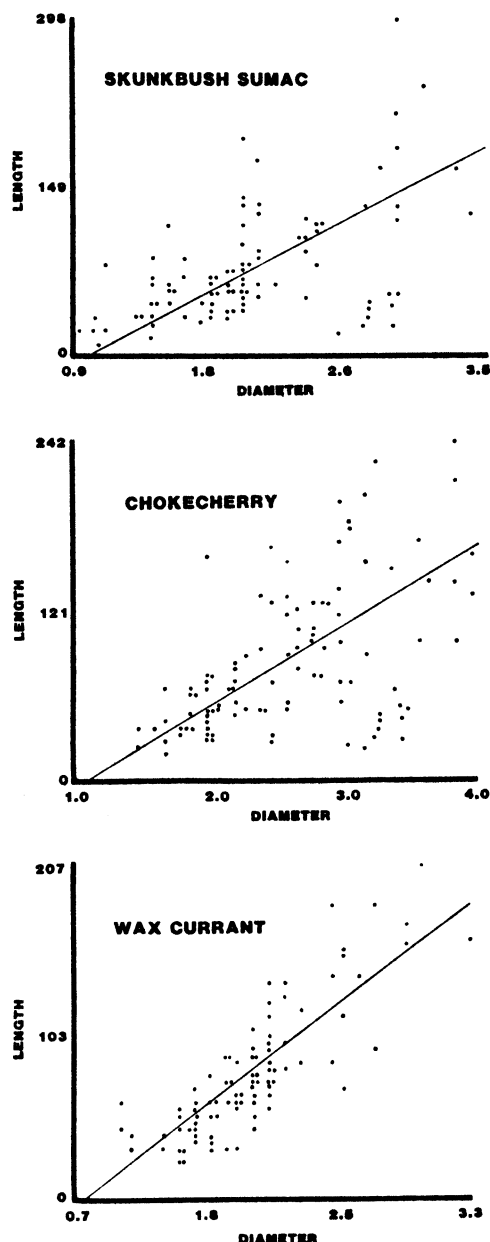


Figure 1.--Relationships of twig length (mm) to twig diameter (mm) for three shrub species in southeastern Montana.

Browsing by animals in this study did not remove large portions of individual twigs. Estimates of the percentages of individual twigs browsed (based on weight estimates) were 26, 37, and 20 percent for skunkbush sumac, chokecherry, and wax currant, respectively. Lyon (1970) suggested big game animals do not browse small percentages of individual twigs, which was contradicted by results of this study. Browsing animals on this study area were pronghorn (*Antilocapra americana*), mule deer (*Odocoileus hemionus*), and white-tailed jackrabbits (*Lepus townsendii*); livestock grazed portions of the study area.

When designing a study from which to develop a model to predict values, some modifications for

sampling are required. Sampling in this study was pseudorandom in that a few very small and very large stems were deliberately sampled to include the extremes. However, for skunkbush sumac there was an order of magnitude difference between the three largest values and the remainder of the data. Preliminary analysis of the skunkbush sumac twig weight data with the model $Y = a + b_1X + b_2X^2$ resulted in an R^2 of 0.90. However, this regression equation was being driven by the three outlying data points (fig. 2). The resulting negative coefficient (b_1) caused the predicted weights of twigs browsed to be greater than the amount available because the function had a minima at a twig diameter larger than the mean diameter at the browse point. If the model was forced through the origin ($Y = bX^2$), the predicted weight of twigs browsed was negative, again resulting

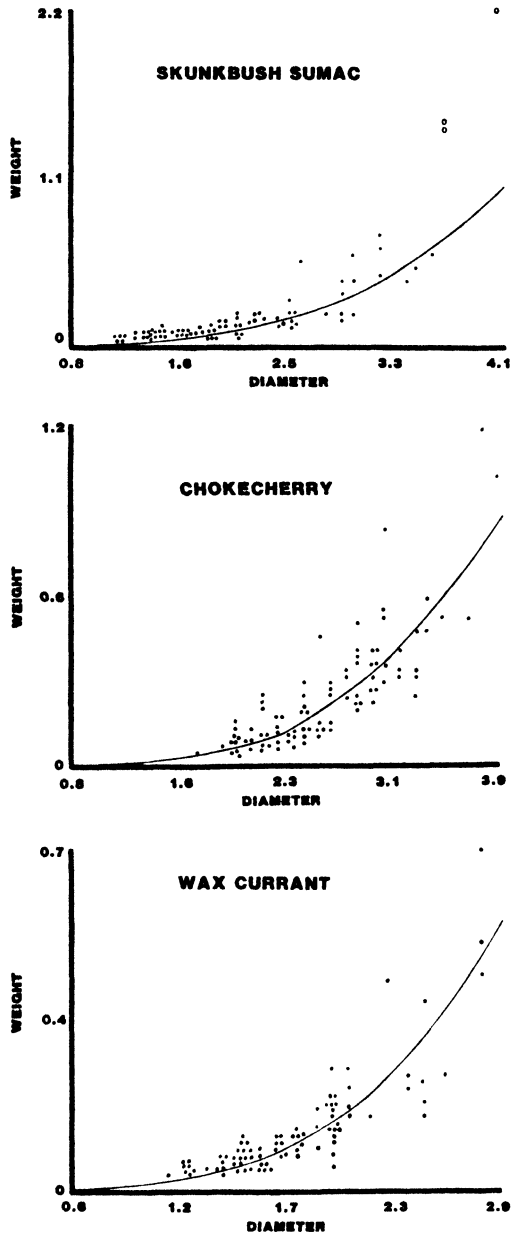


Figure 2.--Relationships of twig weight (g) to twig diameter (mm) for three shrub species in southeastern Montana.

Table 1.--Regression equations to predict length and weight of shrub twigs from twig diameter for three species of shrubs in southeastern Montana

Species	Equation	R ²
Skunkbush sumac	Length = 71.79 (6.1) ¹	0.59
	* (Diameter) - 64.55	
	Weight = 0.007 (0.0004)	0.80
	* (Diameter) ^{3.50}	
Chokecherry	Length = 58.60 (5.8)	0.51
	* (Diameter) - 61.53	
	Weight = 0.004 (0.0002)	0.75
	* (Diameter) ^{4.05}	
Wax currant	Length = 68.75 (5.9)	0.58
	* (Diameter) - 49.97	
	Weight = 0.011 (0.0005)	0.61
	* (Diameter) ^{3.69}	

¹The coefficient.

Table 2.--Estimates of percent utilization using length and weight equations for three shrubs species in southeastern Montana

Estimate method	Skunkbush sumac	Chokecherry	Wax currant
Length	11.1	16.9	4.2
Weight	8.4	11.2	2.0

from the larger twig diameters driving the model. Other analyses that included these outliers resulted in the model $Y = aX^b$ having an exponent (b) of 5.73. The R^2 for this model also was 0.90. Examination of the residuals plot indicated the model was not appropriate. These outliers were sucker type growth and therefore were not included in the final analysis. The resulting model (table 1) and residuals plot suggested this model fit the data fairly well.

In the future, a more selective procedure that results in a scattering of data points throughout the range of twig sizes (stratified random sampling) would be more appropriate. Random sampling of twigs concentrates the data points near the middle portions of the distribution. Without the data points at the upper and lower ends of the range (figs. 1, 2) these distributions could result in linear models that have been reported for twig diameter-weight models (Lyon 1970; Peek and others 1971).

Standardized residuals plotted against standardized twig diameters indicated that there were heterogeneous variances in these data. However, nonuniformity of variances will not introduce serious biases to regression models (National Academy of Sciences 1962: 255) provided the data

are scattered throughout the range and there are no outliers. The residual plots indicated that the regression models derived were appropriate for these data. In any case, it is important to examine the residuals to see how well the model fits the data. Plots of residuals also indicate if nonlinear or weighted models should be used and they display possible outliers.

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