Estimating Snowberry [*Symphoricarpos oreophilus*] Utilization by Sheep from Twig Diameter-Weight Relations

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Abstract

Three procedures were used to estimate snowberry biomass browsed at 3 stocking intensities by domestic sheep on mountain range in southwestern Utah. Two regression equations and (percentage of) grazed stems were compared. Each technique gave different estimates of utilization, which were affected by grazing intensity. The two regression equations we developed distinguished between two kinds of sheep browsing, leaf only and entire stem removal. Sheep usually strip only the leaves and rarely is the entire stem removed. The predictive equations accounted for both methods of browsing and related twig diameters to twig leaf weight (R^2=.89) and twig plus leaf weight (R^2=.90).

Shrub species are major components of arid and semiarid rangelands throughout the world and are important sources of forage (browse) for domestic and wild herbivores. Browse, however, is often considered important only during winter grazing periods or in low rainfall areas as a reserve feed in times of drought (Wilson 1969). Yet on mountain ranges in Utah, snowberry provides an important forage resource for sheep during summer months even when herbaceous vegetation is not limiting. To determine desirable stocking rates for these rangelands requires a method of estimating snowberry production and utilization.

A wide array of shrub sampling techniques has been reported. Recently, emphasis has been placed on developing correlations between biomass and size of specific shrub parts (Rutherford 1979). Regression techniques are then employed to predict leaf or shoot biomass. These techniques eliminate the need for sampling before and after browsing, thus facilitating more efficient and accurate analyses (Basile and Hutchings 1966, Ferguson and Marsden 1977, Jensen and Urness 1981, Lyon 1970, Provenza and Urness 1981). These relationships vary among areas, sites, species, and individual plants (Peek et al. 1971). In addition, browsing intensity often affects the accuracy of these determination techniques (Rutherford 1979).

Our study examined the relationship between snowberry twig diameter and weight, and the usefulness of that knowledge. Three models were compared. Model one estimated amounts of leaves removed, model two estimated amount of intact twigs removed, and model three estimated utilization based on the percent of grazed stems. We used these models to predict sheep utilization of snowberry in a grazing trial conducted during July, 1981, in which utilizations under 3 grazing intensities were compared.

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Study Area

The experiment was conducted on mountain rangeland in southwestern Utah near Cedar City. The study area was located on a high mountain loam range site at an elevation of 2,500 m and consisted floristically of aspen *(Populus tremuloides)* with a snowberry understory interspersed with open areas of grassland and snowberry. Kentucky bluegrass *(Poa pratensis)* and Letterman needlegrass *(Stipa lettermanii)* were important associated grasses. grasses.

Methods

Development of the Predictive Equations

Current year's snowberry twigs exhibit a geometrical growth form. As twigs elongate, older internodes increase in diameter. Thus, there is a direct relationship between mid-internode diameter and twig weight distal to that point. Consequently, equations relating mid-internode diameter to oven dry twig (including leaves) and leaf weight were developed by measuring 100 snowberry twigs.

Twig diameters were measured near the center of selected internodes. A variety of twig size classes and internode locations with respect to the tip were included in the sample. Diameters were measured with a dial caliper to the nearest 0.01 mm. After making the measurement, the twigs were clipped at the point of measurement and oven-dried. Oven-dried twigs were weighed intact, then the leaves were removed and weighed separately. A quadratic function ($Y=B_0+B_1X+B_2X^2+E$) was then fitted to the data (Neter and Wasserman 1964, p. 273) where Y=twig or leaf weight and X=mid-internode diameter.

Application of the Equations

These equations were used to estimate current year's twig growth and utilization of snowberry in small (.4 ha) pastures browsed by sheep. Twenty, randomly located plots (20 cm $\times$ 30 cm) were sampled in 3 pastures, each with a different intensity of utilization, after browsing. Heavy, medium, and light levels of use were based on utilization of snowberry at stocking rates of 0.8, 1.5, and 3.0 ha/AUM. In each plot the diameter of the last intact mid-internode of all grazed twigs was measured. These dependent variables were then used in the previously developed regression equations to estimate current year's growth removed from each plot. Because the regression technique only predicts the amount of snowberry removed, an estimate of biomass remaining on the shrub is needed before total current year's growth is known and can be used in the percent utilization calculation. Therefore all twigs still present in each plot were clipped and weighed. In addition, all ungrazed stems were counted and the percent of grazed stems in each plot was determined from these counts. Extrapolating the biomass removed per plot to the total area of snowberry in each pasture, as determined from aerial photos, permitted estimates for total snowberry biomass removed in each pasture, calculated as follows:

$$U = \left| \frac{\Sigma A}{B} \div C * T \right.$$

where:

U = total grams of snowberry removed from the pasture
A = grams snowberry removed per plot
B = total number of plots sampled in the pasture
C = area per plot

and

T = total area of snowberry cover in the pasture.

Results

Regression equations and functions for the snowberry twigs sampled are presented in Figures 1 and 2. Highly significant *F* values were found but the existence of a significant *F* does not by itself assure that the independent variable, in this case twig internode diameter, can usefully predict Y, twig and leaf weight. To quantify the relationship between snowberry twig biomass and mid-internode diameters, the coefficient of multiple determination, R^2, was calculated (Neter and Wasserman p. 228 and 286). Figures 1 and 2 report and indicate highly predictable relationships. The data do become more variable (larger residuals), however, for larger stem diameters.

The regression lines are within the range of observed values for the independent variable, stem diameters. Most of snowberry stems examined in the study pastures were between .5 and 2.5 mm in diameter, as was the case in earlier studies on the same sites (Schlundt 1980).

Equation Application

Sheep do not generally bite off the entire snowberry stem while browsing. Rather, leaves are usually stripped from the stem. The prediction equation for quantity of leaves stripped from the stem is given in Figure 1, while Figure 2 shows the equation for the amount of whole twig removed. If only one approach is used the more accurate account of snowberry use by sheep is obtained by estimating the amount of leaf removed. If total biomass (twigs plus leaves) removed is considered, utilization is overestimated, especially at higher levels of use (Table 1). Occasionally, whole stems are removed, and these data can be analyzed by use of the total biomass regression equation.

Table 1. Comparison of mean percent utilization estimates of the 3 models at 3 intensities of snowberry browsing.

	Mean percent utilization model		
Level of use	1[1]	2[2]	3[3]
Light	2.3a[4]	6.4a	8.1a
Medium	13.0b	40.8c	50.2c
Heavy	21.8d	58.9e	83.8f

[1]Based on leaf removed only.
[2]Based on removal of entire twig.
[3]Based on percent grazed stems.
[4]Means within rows or columns followed by the same letter are not significantly different at the .01 level.

Under light grazing, sample variability was too great to permit the detection of significant differences among the three utilization estimators (Table 1). In the heavily browsed pastures, utilization estimates based on models 2 (entire twig removal) and 3 (percent grazed stems) differed significantly (Table 3). Model 1 predicted significantly less utilization under both moderate and heavy browsing intensities. Highly significant differences among levels of use were detected by all three models. Variability among plots within pastures decreased as utilization levels increased. At heavier stocking rates, between-model differences are important, especially when total browse removed, rather than percent utilization, is of interest. For example, at the heaviest level of use, estimates of snowberry removal were 68 kg, 182 kg, and 260 kg from models 1, 2, and 3, respectively (Fig. 3). These differences can be quite important when adjusting stocking rates.

Discussion and Conclusions

The snowberry growth form presents range managers and researchers with great difficulty in estimating degree of utilization

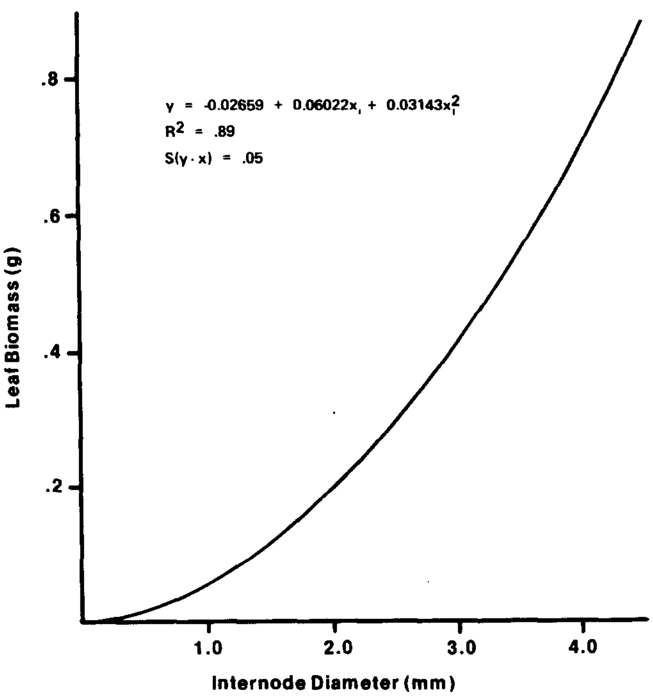

Fig. 1. *Relationship between mid-internode diameter and oven-dried leaf weight for snowberry.*

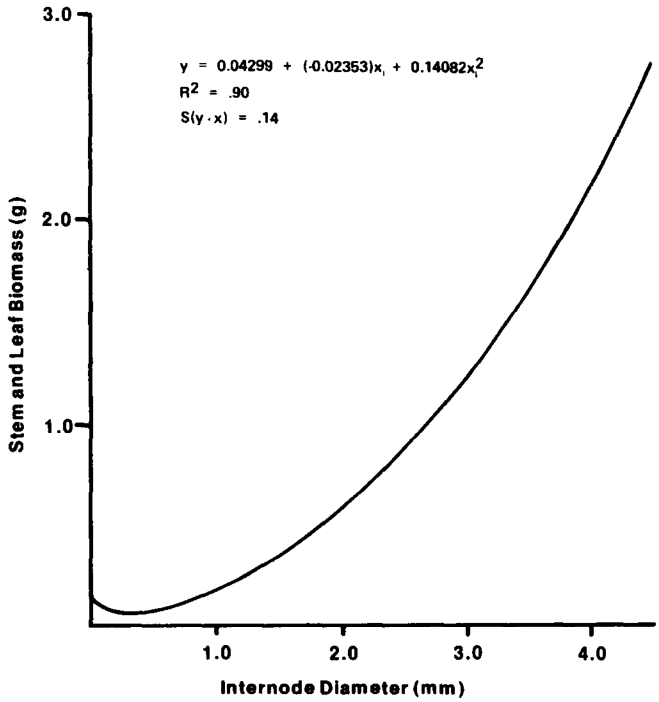

Fig. 2. *Relationship between mid-internode diameter and oven-dried stem (including leaves) weight for snowberry.*

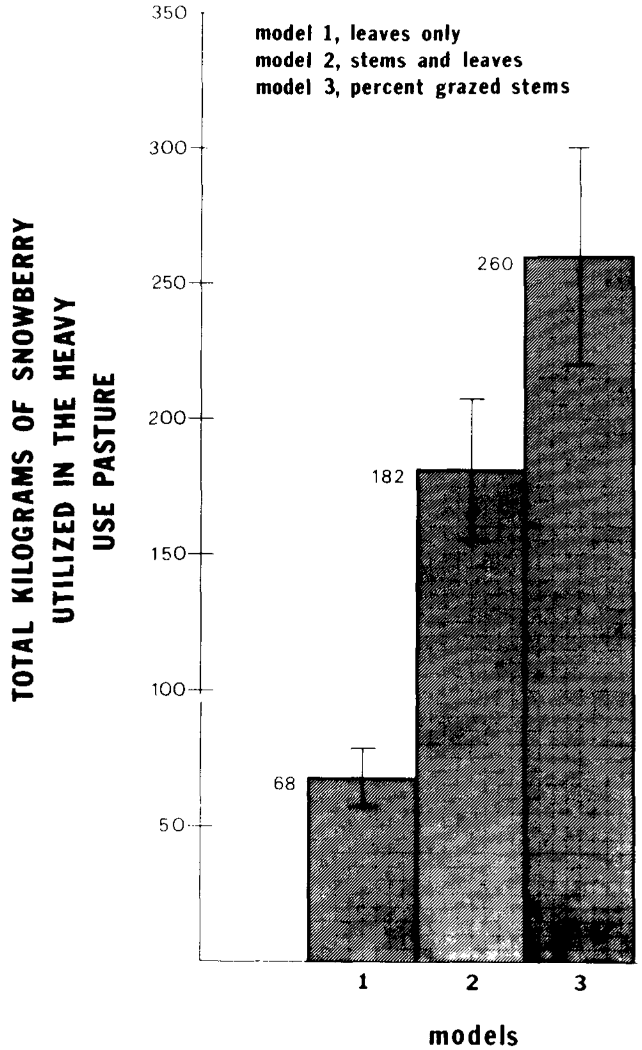

Fig. 3. *Comparison of total snowberry removal estimates of the 3 models at the heavy level of utilization.*

by livestock and wildlife. A simple and repeatable method for equation development involves measuring mid-internode diameters in the field, followed by weighing stems and leaves in the laboratory. Equations can then be developed and used in a one-trip sampling scheme to quickly estimate snowberry utilization. Some differences can be expected in snowberry growth forms among sites. For example, we found that shrubs growing under aspen canopies required different regressions than shrubs growing on open areas, so site-specific equations should be developed. Yearly variation may also exist. In this study, quadratic equations gave the best fit. However, Schlundt (1980) found an equally significant correlation between the cube root of oven-dried twig weight and twig diameter, and other functions may also be useful.

The three models used to predict snowberry utilization provided three different estimates, and the accuracy of the models varied with grazing intensities. For general purposes, the percentage of grazed stems technique may be used to estimate low levels of twig utilization, but values obtained will be somewhat higher than actual use. Stickney (1966) and Jensen and Scotter (1977) found the grazed stem method valid for utilization levels up to 55 or 60%. Our data indicate the relationship becomes invalid for snowberry at utilization levels around 10 percent. A more accurate estimate of browse utilization, especially at high stocking rates, can be made using the predictive equations, noting where stems were actually removed and applying the intact twig model (model 2) only on those measurements. When leaves are stripped clean leaving the bare twig, as usually occurs with sheep grazing snowberry, only model 1 should be applied.

Major advantages of the sampling method described are:

1. The high correlation between mid-internode diameter and twig and leaf biomass of snowberry allows development of predictive equations from a relatively small number of twigs.
2. The weight of snowberry twigs and leaves removed can be accurately estimated after browsing.
3. Current year's growth and utilization can both be estimated at one point in time.
4. Accurate estimates of total snowberry biomass utilization are easily obtained.

Literature Cited

Basile, J.V., and S.S. Hutchings. 1966. Twig diameter-length-weight relations of bitterbrush. J. Range Manage. 19:34-38.

Ferguson, R.B., and M.A. Mardson. 1977. Estimating overwinter bitterbrush utilization from twig diameter-length-weight-relations. J. Range Manage. 30:231-236.

Jensen, C.H., and G.W. Scotter. 1977. A comparison of twig-length and browsed-twig methods of determining browse utilization. J. Range Manage. 30:64-67.

Jensen, C.H., and P.J. Urness. 1981. Establishing browse utilization from twig diameters. J. Range Manage. 34:113-116.

Lyon, L.J. 1970. Length-weight-diameter relations of serviceberry twigs. J. Wildl. Manage. 34:346-460.

Neter, J., and W. Wasserman. 1974. Applied Linear Statistical Models. Richard D. Irwin, Inc., Illinois.

Peek, M.J., L.W. Krefting, and J.C. Tappeiner. 1971. Variations in twig-diameter-weight relationships in northern Minnesota. J. Wildl. Manage. 3:501-507.

Provenza, F.D., and P.J. Urness. 1981. Diameter-length-weight relations for blackbrush *(Coleogyne ramosissima)* branches. J. Range Manage. 34:215-217.

Rutherford, M.C. 1979. Plant-based techniques for determining available browse and browse utilization. Bot Rev. 45:203-208.

Schlundt, A.F. 1980. Common use grazing studies on southern Utah summer range. Ph.D. dissertation, Utah State Univ., Logan.

Stickney, P.F. 1966. Browse utilization based on percentage of twig numbers browsed. J. Wildl. Manage. 30:204-206.

Wilson, A.D. 1969. A review of browse in the nutrition of grazing animals. J. Range Manage. 22:23-28.