TECHNICAL NOTES

Estimating Browse Production by Deerbrush [*Ceanothus integriramus*]

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Abstract

This architectural model is designed to significantly refine browse weight estimates for deerbrush (*Ceanothus integriramus*). Basal diameter of branches arising from the primary stem (2nd order stems) predicted leaf and branch weights with $r^2 = 0.97$ using an allometric transformation in linear regression. Estimates based on secondary stem basal diameter rather than terminal shoots may be useful in a large number of similar shrub species.

Shrubs produce a significant amount of the forage in forests and brushlands. Yet layering, poorly defined shrub canopies, and ill-defined current annual growth may make accurate estimates of browse production difficult to achieve. Forage production varies within and among species, with age of the plant, with season of the year, among years, and with site. Developmental response to browsing may be highly variable. For example, chamise (*Adenostoma fasciculatum*) stems resume growth shortly after browsing, whereas deerbrush (*Ceanothus integriramus*) stems do not. Animal accessibility to shrub production further complicates estimates of carrying capacity on browse ranges.

Attempts to measure shrub browse production have centered on a few basic techniques, including tagged twig methods, ocular estimates, and clip and weight methods. Regression methods have been widely used to estimate total biomass, current annual production, and utilization in shrubs while reducing sampling costs. Several authors have used plant variables such as height, crown volume, and current annual stem diameter and length to predict weights of different species or plant parts within species (Schuster 1965, Lyon 1968, Peek 1970, Ohman et al. 1976). Basile and Hutchings (1966) and Fergus and Marsden (1977) used current annual twig diameter, length and weight relations to predict unbrowsed twig weight as method to estimate utilization in bitterbrush (*Purshia tridentata*). Regression equations may predict browse production with high precision, but equations generally apply only to specific situations.

Research methods have overcome some of the problems associated with accurate browse estimation. Bitterbrush, which has clearly defined growth, exemplifies a species adequately described and measured. We describe a method for predicting stem and leaf biomass in a less easily measured, but important species.

Deerbrush is the most important summer browse species for livestock and big game in the 5-million hectare ponderosa pine belt in California (Cronmiller 1953). As an open-crowned deciduous shrub up to 5 m tall, with slender dropping branches and poorly defined annual growth, deerbrush typifies a large group of

difficult-to-measure browse species. Our method proposes a new way of looking at shrub architecture which works to predict leaf and branch biomass in deerbrush. It may have applicability to similarly difficult-to-measure browse species.

Method

Although all the leaves of deerbrush represent current annual production, annual stem production is difficult to measure and characterize. A complex branching pattern and indeterminate growth of individual stems rule out simple approaches based on current annual stem growth, such as those used for bitterbrush.

The proposed model of stem architecture categorizes branches as 1st, 2nd, 3rd, 4th order. The 1st order of primary stem forms the main supporting structure for the plant and has no directly attached leaf clusters. (On deerbrush a leaf cluster is composed of 3 leaves attached directly by the leaf pedicel to the stem). All lateral branches arising from the primary stem are designated as 2nd order branches. Designation of the order of a branch is based on its attachment to the primary stem. This branching model forms a very useful framework for estimation of stem and leaf biomass in deerbrush, and with further testing may have wide applicability in shrubs of similar lifeform.

Twenty-five randomly selected unbrowsed deerbrush plants were cut off at ground level in July and brought into the laboratory at University of California's Blodgett Forest Research Station near Georgetown, Calif. Shrubs were mature, 1-3m tall, and obviously vigorous, growing at 1300-1500m elevation.

Secondary stems randomly selected from the 25 shrubs were cut off as close to the primary stem as possible. Average basal diameter were recorded with calipers for each of 60 2nd order stems. The leaves and branches were weighed separately, bagged, dried for 24 hours at 70°, C and reweighed.

Results and Discussion

Regression analyses using an allometric ($Y = ax^b$) transformation indicate that a linear model using 2nd order stem basal diameter (X) to predict leaf weights (Y) accounts for 97% of the variability in Y ($r^2 = 0.97$), (Fig. 1). Second order stem basal diameter also predicts leaf weight alone with an r^2 equal to 0.83 (Fig. 1). Basal diameter is also positively correlated with dry stem weight ($r^2 = 0.97$) X (in stem wt. = $3.58 - 3.33 \ln X$).

The regression model is less robust for prediction of leaf weights than stem weights due to variation in leaf size, leaf drop, and number of leaves per 2nd order branch. Stem weights closely correlate with stem basal diameters because the amount of tissue a branch supports is related to its diameter at point of attachment.

To determine stem and leaf biomass of deerbrush, measure and record the basal diameters of randomly selected 2nd order stems. Our equations may then be applicable to determine weight per bush or overall biomass, with the degree of precision largely

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Fig. 1. Relationship between leaf weight, total weight, and secondary stem basal diameter in deerbrush. $N = 60$ stems, $r^2 = 0.97$ for total weight and $r^2 = 0.83$ for leaf weight on secondary stems basal diameter. Relationships are significant at $P < 0.001$ by analysis of variance. For total weight: on secondary stem basal diameter MSE regression = 97.815 and MSE residual = 0.052. For leaf weights on secondary stem basal diameter MSE regression = 76.759 and MSE residual = 0.271.

dependent on the number of 2nd order stem measured, the age of the plants being studied, and plant vigor. Because of the high correlation between basal diameter and total weight, relatively few samples give high precision. For example, 10 randomly selected twigs yield a coefficient of variation of only 7%. Most of the variation in weight is explained by basal diameter.

Researchers interested in shrub production may find the architectural model described a useful way to focus thinking about stem biomass and leaf production in shrubs similar to deerbrush in life form. The ease and precision of basing regression estimates on 2nd order stems rather than on terminal shoots, as has been done in the past, should be applicable to many other shrub species for measures of production and utilization.

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