Browsed-class Method of Estimating Shrub Utilization

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Abstract

The browsed-class method has been developed to measure shrub utilization based on total weight of the plant. It uses growth form to place grazed shrubs into 6 browsed-classes. The method is fast, statistically sound, relatively free from personal bias, easy to learn and use, and can be used in research or land management. In a 10-year case study to determine proper use of hairy mountain-mahogany, plants were clipped initially and then reclipped once each year in the fall or winter over a 7-year period at 0, 10, 30, 50, 70 and 90 % levels based on total weight of the plant. This was followed by a 2-year recovery study. Parameters studied were numbers, length, and production of twigs; area of live and dead crown cover; and general vigor and seed production. All criteria, except area of live crown cover, indicated that 50% of total weight was proper use of hairy mountain-mahogany.

Millions of hectares of rangeland are dominated by shrubs. Many of these shrubs are low quality species invading or increasing at the expense of valuable forage species. However, many shrubs are valuable forage species that can be increased in abundance by proper use, treatment, and management. A necessary tool for good management is a reliable method of evaluating proper use of shrubs.

Most browse utilization methods are based on ocular estimates or measurements of twig length, numbers, or weight to evaluate the percentage of current annual twig growth utilized (Dasmann 1948, NAS-NRC 1962, Smith and Urness 1962, Smith et al. 1963, Basile and Hutchings 1966, Stickney 1966, and Jensen and Scotter 1977). Methods using measurements are generally time consuming, which often results in inadequate sample size. Faster methods based on ocular estimates are generally subjective, require extensive training, and have an uncertain degree of accuracy. To help solve these problems the browsed-class method, which uses photo guides based on total plant weight, was developed to estimate browse utilization. Also, since there were no data on proper use based on total shrub weight, a 10-year study was initiated to measure the effects of 6 degrees of clipping on mountain-mahogany (*Cercocarpus montanus* var. *paucidentatus* (S. Watson) F.L. Martin). The method is discussed in Part I and the utilization case study in Part II.

Part I. The Browsed-class Method

The browsed-class method is similar in some respects to the hedged and form classes used by the Forest Service and other

agencies to estimate past use and vigor or condition of browse species (Dasmann 1951, Patton and Hall 1966, U.S. Forest Service 1981). The method uses photo guides of shrubs based on height-weight curves to place randomly selected plants in 6 browsed classes—0, 10, 30, 50, 70, and 90% use (Fig. 1). Since the classes are based on height-weight curves, they evaluate percentage of weight utilized. Also, since estimates are based on growth form, variations in height due to wet or dry years, deep or shallow sites, fertile and unfertile soils, age, etc., are automatically adjusted for by the eye.

The method is a departure from conventional shrub utilization methods in that estimates are based on total weight of the plant rather than on current twig growth. As a result it primarily measures trend in utilization (in comparison to previous years estimates) but also shows the level of current use (in comparison to ungrazed plants). Since shrubs do not die back to the ground each year, trends in utilization are sufficient for shrub management. When trends show that utilization is approaching or exceeding proper use, adjustments can be made in game and/or livestock
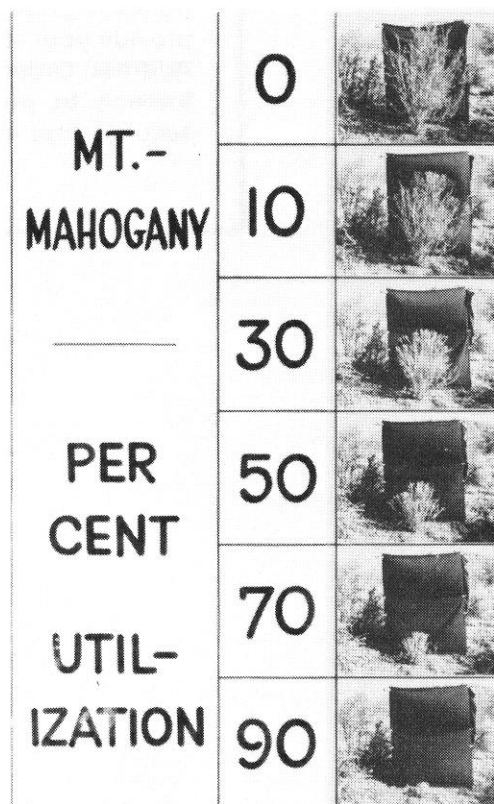

Fig. 1. *Photo guide of hairy mountain-mahogany used for estimating degree of utilization by the browsed-class method.*

numbers and/or management to correct the situation. Subsequent utilization estimates will determine if adjustments are adequate.

Test and Analysis of the Browsed- Class Method

The accuracy of the browsed-class method was tested by 4 students using a photo guide for hairy mountain-mahogany on 72 clipped plants in 3 Forest Service exclosures. Hairy mountain-mahogany is a dominant in the upper elevations of the Arizona chaparral (Nichol 1952, Lowe 1964). The plants were clipped to browsed-class percentage levels using height-weight curves as a guide. The exclosures were the Buckman Flats and Doce exclosures 15 km west of Prescott, Ariz., and the Stockton Pass exclosure approximately 50 km north of Willcox, Ariz. None of the examiners had used the browsed-class method previously although all were acquainted with the similar grazed-class method for grasses and forbs (Schmutz et al. 1963) and one had helped clip some shrubs several years before.

There were two main objectives to the test. One was to determine the length of time (or experience) needed by the estimators to obtain certain levels of accuracy and the other was to determine the size of samples required by experienced estimators to obtain various degrees of accuracy.

Training Needed by Inexperienced Personnel.

To determine the amount of experience needed for a given degree of accuracy, repeated estimates were made on the clipped plants at intervals over several months for a total of 840 observations. The estimates were then compared with the mean of the 6 clipped browsed-class percentages. Results showed that after 4.5 hours of experience average estimates of browse utilization on hairy mountain-mahogany by the 4 estimators using the browsed-class method varied less than 5% from the browsed-class mean at the 95% level of confidence (Fig. 2). This represents a high degree of accuracy compared to other methods used. Similarly, the narrow confidence intervals about the estimated means after 4.5 hours practice indicate a high degree of precision. Three of the 4 estimators reached the above degree of accuracy after 2.5 hours of practice. The high degree of accuracy confirms that there is a close correlation between growth form and weight estimates when estimates are made by experienced personnel. Also, the large sample possible within a given unit of time provides for a more representative sample of the area being surveyed and errors due to sampling or variations in growth form are compensating. As with the grazed-class method, the trend of the confidence intervals above the browsed-class mean shows that estimators tend to under-estimate utilization when the method is first used (Fig. 2).
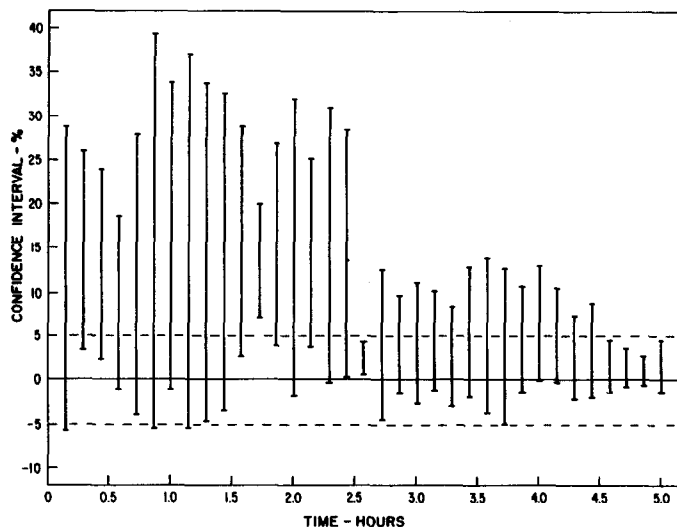

Fig. 2. *Confidence intervals of utilization estimates on hairy mountain-mahogany by 4 estimators using the browsed-class method over time at the 95% level of confidence.*
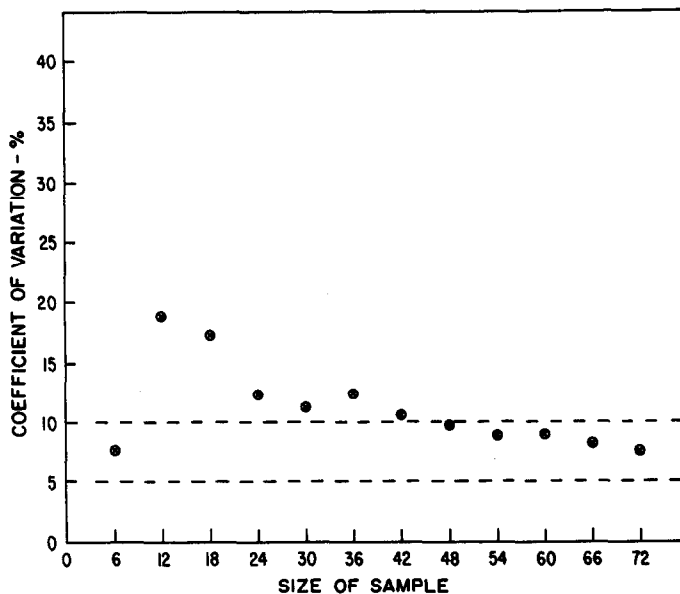

Fig. 3. *Relationship of sample size to coefficient of variation at the 95% level of confidence by 4 estimators after 3- to 5-hours experience with the browsed-class method.*

Sample Size Needed by Experienced Personnel

To test the size of sample needed by experienced personnel for a desired degree of precision, estimates were made after 3- to 5-hours experience by the 4 estimators on the 3 study areas and analyzed (Fig. 3). Results show that under these conditions on the average a sample size of 50 plants will give an estimate of utilization within 10% of the browsed-class mean at the 95% level of confidence. Projection of these data indicates that on the average a sample size of 110 plants would be required for an estimate within 5% of the browsed-class mean at the 95% level of confidence. Variations in coefficients on the left side of the chart are due to a combination of small sample size and lack of experience by the estimators. Sample sizes for other key species may vary from these results.

Use of the Browsed-Class Method

As indicated, the browsed-class method uses photo guides of browse species (Fig. 1) to place plants of key species into 6 grazed classes. Plants are recorded by dot-dash tally, totalled by classes and converted to percentages (Fig. 4). Each key species should be sampled separately. If more than one estimate is desired a second key species or key area should be sampled. If 50-plant samples are taken, the class totals are doubled for class percentages. If 100-plant samples are taken, class totals equal class percentages. For odd-sized samples the individual class percentages are divided by the total sample. Sample class percentages are then multiplied by the respective browsed-class percentage (as a decimal fraction) and products added for the current level of browse utilization.

In general, the best sampling procedure is to stratify range areas into reasonably uniform soil units or sites. Then, as far as possible, sample the areas crosswise to drainages, soils, slopes, and trails to obtain a representative sample. To get good distribution of relatively unbiased samples, take them nearest the toe at regularly paced intervals in straight lines. To facilitate locations of plants, select plants nearest the toe within a 3- to 4-meter strip on either side of the sample line and ahead of the examiner. Only plants available for browsing, usually less than 1.5 m in height, should be sampled. Sample size will vary with degree of precision desired. Tests show that a 50-plant sample can be taken in 15 to 30 minutes and a 100-plant sample in 30 to 60 minutes depending on roughness of terrain and frequency of plants being sampled. Estimates on shrubs can be made at any time of the year but are most useful at the end of the grazing season or year.

RANGE UTILIZATION ESTIMATES

BROWSED-CLASS METHOD

LOCATION: KEY SPECIES:			
BROWSED CLASSES	DOT–DASH TALLY	BROWSED PLANTS – %	CURRENT USE–%
0	⊠	10	0
10	⊠ ⊠ ⁻⁻ ∴	25	2.50
30	⊠ ⊠ ⊠	30	9.00
50	⊠ ⊠	20	10.00
70	⊠	10	7.00
90	⁻⁻ • •	5	4.50
TOTAL CURRENT SPECIES USE–%			33

Fig. 4. *Method of recording estimates and calculating degree of utilization by the browsed-class method.*

Proper annual grazing capacity per se cannot be estimated from a browsed-class estimate because there is no assurance whether the current level of use represents the current year's use or an accumulation of several years of use. However the estimate does show the current level of use and its relationship to proper use can be estimated with the following formula:

$$\text{Current relative percentage of proper use} = \frac{\text{Estimate of current level of use-\%}}{\text{Percentage of proper use}}$$

For example, if the estimate of the current level of use for the key species is 30% and its percentage of proper use is 50%, then the current relative percentage of proper use is 30 ÷ 50, or 60%. From this it can be assumed that the current level of use can be increased 40% (20 ÷ 50) without damage to the vegetation. Also, a comparison of the current level of use with previous years estimate can show trends in utilization.

In addition to current relative percentage of proper use and trends in utilization, the method can be used to calculate relative use of species, season of use, distribution of grazing, topography and soil effects, and the effects and economics of range treatments and practices. Treatments and practices that can be studied include water development, salting, fertilization, fencing, grazing treatments, and changes in the class of animals grazed.

The browsed-class method uses the key species-key area concept to estimate the current level of use and current relative percentage of proper use. This concept assumes that when one or more key species of a key area has been properly utilized in relation to the associated species and the conditions on the range, the best possible use of the area has been made. The method can be used in key areas as an index to utilization of the pasture as a whole, or over the entire pasture to estimate the various levels and distribution of grazing. If the key browse species used is the most palatable browse species, the level of current use in relation to the proper degree of use for that species will be the guide to proper use. If the key species used is a secondary browse species, then a proportionately lower percentage of use that will insure proper use of the most palatable key species must be used as a guide. In mixed grass-shrub areas where grasses are more palatable than the browse species for the animals being grazed, grasses will be the key species used to mea-

sure proper use of the range. However, if the browse species are used in a different season than the grasses, both may be used, each for its corresponding season of use. Also, if different areas are used by different classes of animals, similar adjustments in estimates will be needed. To determine relative use between browse and/or grass species, separate utilization estimates may be made on several species in the same key area at the end of the grazing season or year.

The use of photo guides to estimate browse utilization promotes consistency, facilitates rapid estimates, and simplifies calculations. The photo guide promotes consistency and accuracy because it provides a standard for comparison. Estimates are rapid because a quick comparison of the plant with the guide enables the surveyor to place it in the closest browsed class. The guide which shows various degrees of use also facilitates estimation of irregular use of plants. Mathematics are simple because estimates are recorded into browsed classes by dot-dash tally, totalled and converted to percentages by classes, multiplied by the respective browsed-class percentage (as a decimal fraction) and products added for the current level of browse utilization (Fig. 4). The validity of using classes to estimate utilization instead of specific percentage estimates was tested on grasses using the grazed-class method and was found to be accurate within one-tenth of 1 %(Schmutz et al. 1963).

Because of excessively woody stems or hedged appearance of some ungrazed shrubs, it may not be possible to develop useful photo guides for all species. However, they are not needed on all species as long as guides on representative species are available. Also, patterns of use will vary for different classes of animals. The pattern of use for the enclosed photo guide for hairy mountain-mahogany (Fig. 1) is typical for these plants when grazed by cattle and deer. Patterns of use by deer alone or by other game species will probably be different. Also, patterns of use by the same classes of animals on other browse species will probably be different. However, the photo guides offer a standard against which these use patterns can be judged, particularly at the lighter more critical levels of use.

Developing Browsed-Class Photo Guides

Photo guides for shrubs, like grasses (Schmutz et al. 1963), will need a close fit between the browsed-class percentages of the guide and the height-weight curves of the plants photographed. Also, the photo-guide plant should have an average curve for the species so that variations in growth form will be averaged. The following procedures can be used to develop guides.

1. When plants are in full growth, locate 5 to 7 average plants of a given species and select a representative basal branch (like a pie wedge) for larger shrubs and the whole plant for smaller shrubs. Beginning at the top of each plant or branch, measure and clip the whole stem or plant into 5 to 7 sections (longer at the top and shorter at the base) and put each section in individual labeled paper sacks. Make and record all section height measurements from the base of each plant using the average of the 3 tallest twigs of the plant or branch for total height. Then average the total heights of the clipped plants and branches for average total plant height.

2. Oven dry and weigh each shrub section and calculate the net total weight in each section. Then, beginning at the top of the plant or branch, total the cumulative weights for the various sections and calculate the cumulative weight percentages for each section by dividing the cumulative weight total for each section by the total weight.

3. Beginning at the base of the plant, cumulate the heights of the various sections of each clipped plant or branch. Then adjust the section increment heights of the individual plant or branch to the average plant increment heights as follows:

$$\begin{array}{c}\text{Adjusted heights}\\\text{of individual}\\\text{plant increments}\\\text{to average plant}\\\text{increments}\end{array} = \frac{\begin{array}{c}\text{Average total}\\\text{height of plants}\\\text{and/or branches}\end{array}}{\begin{array}{c}\text{Total height of}\\\text{individual}\\\text{plant or branch}\end{array}} \times \begin{array}{c}\text{Increment heights}\\\text{of individual}\\\text{clipped plant or}\\\text{branch}\end{array}$$

4. Plot the cumulative weight percentages of each individual plant or branch increment against its adjusted cumulative height increment as shown in Figure 5. Use the lower left hand corner as zero on each scale and plot curves for 5 to 7 plants and/or branches of a given species on the same chart. Then, by eye, plot an average photo guide curve using the 5 to 7 plants as a guide. From this curve determine the average height increments for the 6 browsed-class percentages 0, 10, 30, 50, 70, and 90.

5. Return to the field and select 4 to 6 average appearing plants of a given species for use in making a photographic guide. Using the increment heights for the 6 browsed-classes read from the average photo-guide curve of a given species, determine the clipping heights for the individual photo plants as follows:

$$\text{Clipping heights of classes for individual photo guide plants} = \frac{\text{Total height of photo plant}}{\text{Total height of average plant}} \times \text{Browsed-class heights of average photo-guide curve}$$

Use the adjusted browsed-class heights for each individual photo plant to photograph it as unclipped and 10, 30, 50, 70, and 90% clipped heights, then clip the last section to ground level. Sack plant clippings separately, oven dry, weigh, calculative weight increments and weight percentages, and plot weight percentages against respective height increments adjusted to average heights as in section 1-4 above. Determine if the curve of at least one plant is average and if the browsed-class percentages of the clipped plant closely match the standard browsed-class percentages (within 2 or 3 percentage points). If a close match is obtained, trim the browsed-class photos and rephotograph them on a photo-guide background (see Fig. 1). If not, return to the field and photograph average plants until a close fit is obtained.

Experience has shown that photographs taken from a low angle give better photo-guides for low shrubs and mid-level is best for plants up to 1.5 m in height. Taller plants are usually unavailable for grazing and should not be used. A black velour background
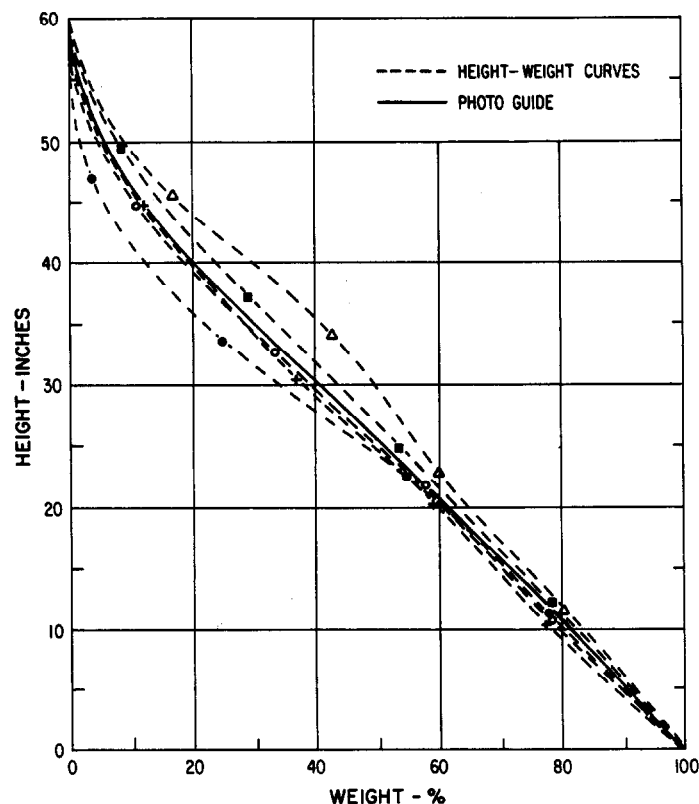

Fig. 5. *Height-weight curves for hairy mountain-mahogany. The photo-guide line shows the average curve needed for photographing and checking the photo-guide plants.*

gives sharper plant outlines and reduces glare. A yellow or green filter increases contrast.

Previous studies showed that a single photo guide properly developed for an average plant and a typical site can be used for a specific grass without serious error throughout the Southwest on all sites in wet and dry years (Schmutz 1978). While there was some variation in growth form, these variations were averaged out with the large sample possible. Photo guides for individual shrub species probably can be used over similar wide areas.

Part II. Proper Use of Hairy Mountain-Mahogany Based on Total Plant Weight

A case study was conducted in the Buckman Flats, Doce, and Stockton Pass exclosures described above on the same clipped plants. In each exclosure there were 4 replications of hairy mountain-mahogany plants clipped at 0, 10, 30, 50, 70, and 90% levels of total plant weight (Fig. 1) using height-weight curves as a guide (Fig. 5). The same plants, except the unclipped plants, were reclipped at their respective levels once each year in the fall or winter for 7 years. The current twig growth on the unclipped plants was clipped only once (at the end of the 7th year). Before reclipping, all plants were evaluated for live and dead crown cover, number of twigs by classes (0, 1-5, 6-20, 21-50, 51-100, and 101+), and length of 5 longest twigs selected in the center and N, E, S, and W perimeters of each plant. Following these measurements all current twig growth above the original clipped level was removed, oven-dried, and weighed to determine yield. After completion of the clipping study, the shrub measurements, except yield, were made for 2 years to measure recovery of the shrubs from the clipping treatments, and ocular estimates were made to evaluate the effect of intensity of clipping on general plant vigor and fruit production. Concurrently with the above studies, nutrient analyses were made to determine the effect of clipping on nutrient content of twigs, stems, and leaves.

Twig Production and Proper Use
Twig production on shrubs largely ceases after shrubs mature, otherwise they would become trees. However, removal of twigs or stems usually stimulates regrowth. Stimulation of average twig production for the average of all 3 exclosures was highest at the 50% clipping level (Fig. 6) but this production was not significantly greater at the .05 level of significance than the other clipped levels, except the 90% level, because of wide variations in production between exclosures. Separate exclosure analyses showed that twig production at the 50% level was consistently greater than the 70 or 90% levels but not the 10 and 30% levels. Therefore, these data show that utilization greater than 50% of the total weight of the plant is detrimental.

Twig Growth and Proper Use
The greatest number of twigs was also produced on the plants clipped to 50% of total weight (Fig. 6). These numbers were not significantly greater at the .05 level of significance than those on the 30 and 70% clipped plants. Similarly, the 30, 50, and 70% plants produced the longest twigs (average of 5 longest) and they were significantly longer than those on the 0, 10, and 90% plants (Fig. 6).

Crown Cover and Proper Use
As expected, area of live crown cover was significantly reduced by the various degrees of clipping (Fig. 6). At the .05 level of significance, live crown cover was significantly greater at the 0 and 10% clipped levels, intermediate at the 30 and 50% levels, and smallest at the 70 and 90% levels. The 50% level of clipping, which reduced the crown cover about 50%, actually was not detrimental since it stimulated twig numbers, length, and production to their highest levels.

The area of dead cover was lowest at the 50% level, but not significantly so except compared to the unclipped plants (Fig. 6). The percentage of dead crown cover compared to total crown cover was also lowest (2.1%) at the 50% level but was highest
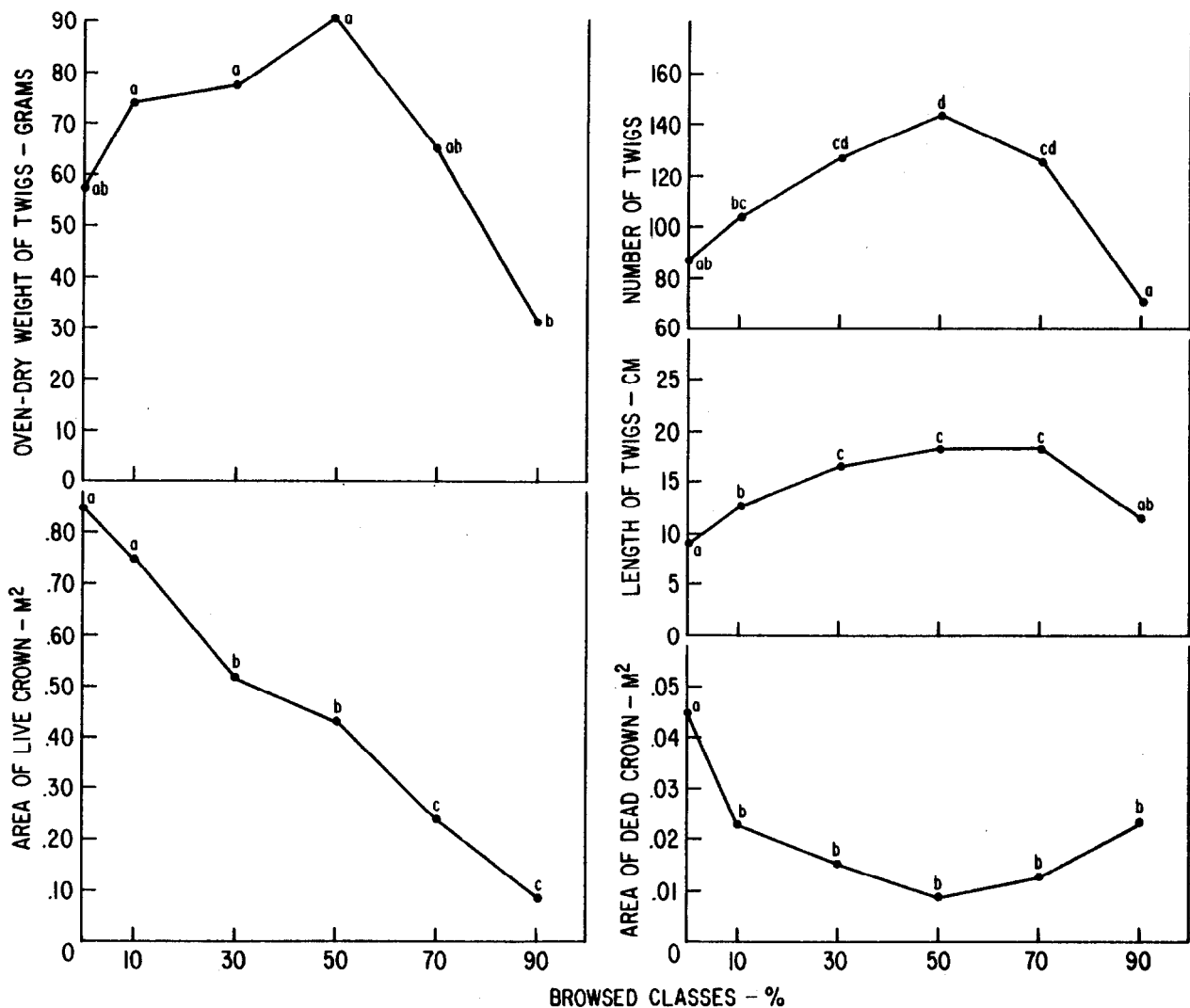
Fig. 6. *Effects of 8 annual clippings at 6 browsed-classes on the yield, crown cover, and twig growth of hairy mountain-mahogany plants in the Arizona chaparral. Means followed by different letters are different at the .05 level of significance as measured by the LSD method.*

(21.7%) at the 90% level. Intermediate percentages were 5.1 and 5.2% at the 0 and 70% clipping levels and 3.0 and 2.8% at the 10 and 30% levels, respectively.

Recovery Following Clipping

To evaluate recovery following clipping, estimates were made for 2 years on live and dead crown cover, length and number of twigs, plant vigor, and fruit production. Live and dead crown cover varied little from previous clipped classes, respectively. Annual twig growth on the clipped plants during the 2-year period averaged about the same per year as in previous years except on the 90% clipped plants where the total 2-year growth only equaled the average yearly growth of previous years. The number of twigs did not change significantly during the 2-year recovery period on the 0, 10, 30, and 50% clipped plants but decreased 19% on the 70% and 50% on the 90% clipped plants. Twigs appeared in good vigor on all plants in all areas except the 90% clipped plants where vigor was poor. During the 2-year recovery period no fruits were produced on any plants in the Buckman Flat exclosure, a droughty site. On the Doce and Stockton Pass exclosures, fruits varied from few to numerous with abundance in inverse proportion to the degree of clipping.

These results show that recovery was good on all plants except those clipped at the 90% level. Other shrubs may respond differently depending on species and season, intensity, and frequency of clipping (Cook and Child 1971, Trlica et al. 1977).

Effect of Clipping Intensity on Nutritive Content

Nutrient analyses were made to determine if the degree of clipping had a significant effect on the carbohydrate, nitrogen, and phosphorus content of the mountain-mahogany twigs. No significant differences were found. These results conform to the findings of Dietz (1965) and Shepherd (1971). Checks also substantiated the findings of Dietz that leaves of twigs were higher in nutrients than twig stems.

Conclusion on Proper Use

All criteria used in this study, except area of live crown cover, indicated that 50% use of the total weight of hairy mountain-mahogany should be the objective of proper management. In all cases the 50% level rated equal to or better than the 30 and 70% levels, nearly always better than the 0 and 10% levels, and always better than the 90% level. This compares with the result of Neff (1965). Using a different clipping procedure on Buckman Flats exclosure (based on current twig growth only), he concluded that 75% of total current twig growth was proper use on hairy mountain-mahogany.

In situations where the 50% level of use will result in detrimental effects to other desirable plants a lower level of use should be the objective. Also, since this study simulated seasonal fall and winter use, a different level of use may be desirable under other conditions, especially where repeat grazing occurs. However, the near 100% level of current twig clipping used in this study would balance

out, at least in part, the effects of repeat clippings. In any case the levels of clipping used in this study indicated that hairy mountain-mahogany is highly resistant to grazing.

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BRANDAIDS Needed?