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Technical Note: Test of observer variability in measuring riparian shrub twig length

FREDERICK C. HALL AND TIMOTHY MAX

Authors are senior plant ecologist, Natural Resource Unit, USDA Forest Service, and Station Statistician, Pacific Northwest Reserach Station, Portland, Ore.

Abstract

Measurement of riparian shrub twig length before and after use should yield a useful utilization index. A first step towards determining utilization is measurement of twig length. This study appraised variability between 15 observers for measuring dormant season twig length on riparian alder (*Alnus incana* (L.) Moench) shrubs. Ten streamside shrubs were selected on which 5 branches consisting of 5 twigs each were tagged below the fifth twig for a total of 250 twigs. Fifteen experienced people independently measured twigs on the same day after instruction in the method. Data were analyzed by hierarchical analysis of variance for length of twigs by branches, by shrubs, and by observers. Variation among observers within a branch was about twice the size of variability among shrubs and represented 20% of the total variation. Items contributing to observer variability were measurement of dieback, selecting the twig end or live bud for measurement, inclusion of short lateral leaf stubs in measurements, and selection of a crotch from where the twig is measured. These results clearly illustrate major difficulties in trying to measure riparian shrub utilization.

Key Words: twig measurement, twig browsing, riparian shrubs

Resumen

La medición de la longitud de ramas tiernas (ramillas) de arbustos ribereños antes y después de ser consumidos debe producir un índice de utilización útil. El primer paso para determinar la utilización es la medición de la longitud de las ramillas. Este estudio cuantificó la variabilidad entre 15 observadores para medir la longitud de las ramillas de arbustos de "Alder" ribereño (*Alnus incana* (L.) Moench) en la época de dormancia. Se seleccionaron 10 arbustos en los cuales se etiquetaron 5 ramas consistentes de 5 ramillas cada una, teniendo un total de 250 ramillas, cada rama se etiqueto debajo de la quinta ramilla. 15 personas experimentadas midieron en forma independiente las ramillas, todas las mediciones fueron hechas el mismo día después de que se explico el método. Los datos de longitud de las ramillas por rama, arbusto y observador fueron analizados por un análisis de varianza jerárquico. La variación entre observadores dentro de una rama fue casi el doble que la variación entre arbustos y representó el 20% de la variación total. Los detalles que contribuyeron en la variabilidad del observador fueron, la medición de material muerto, la selección de la terminación de la ramilla o de la yema viva para medir, la inclusión de tocones laterales de hojas en la medición y la selección de bifurcación de la rama donde la ramilla debe ser medida. Los resultados ilustran claramente las principales dificultades para medir la utilización de arbustos ribereños.

Monitoring livestock use in riparian areas is a significant concern as discussed in several symposia (Clary et al. 1991, Platts et al. 1987, Tellman et al. 1993). One aspect of this concern is utilization of riparian shrubs. There are 3 primary reasons for limiting shrub use: (1) maintain shrub vigor, (2) maintain or increase shading along streams, and (3) enhance recruitment and growth of replacement shrubs. A primary question is how to identify shrub use that prevents achievement of management objectives. One system is termed browse removal (USDI Bureau of Land Management 1996) where utilization is determined by measuring twig lengths before and after browsing to estimate percent removed. A first step is to appraise methods for measuring twig length.

One factor to evaluate in measuring twig length is variability between observers. This problem should be addressed because the person installing a sampling system probably will not be the one reading it later on. Observer variability has not been the subject of much research as Elzinga and Evenden (1997) indicated in their annotated bibliography on vegetation monitoring. Of 1,406 references cited, only 43 (3%) mentioned the topic. Of these, only 20 specifically dealt with evaluating observer variability, none of which dealt with twig measurement or determination of shrub utilization.

We conducted an earlier test comparing current annual leader length with browsed leader length, as determined by seven 2-person teams. Utilization measurements varied from 32% to minus 41%. Minus 41% means the leaders that had been browsed were 41% longer than unbrowsed. Discussion with participants disclosed major observer bias in selecting twigs or leaders to measure as well as problems in evaluating regrowth and multiple branching in response to terminal bud removal.

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The evaluation reported here was an attempt to find a reliable method for measuring shrub twigs as a first step toward determining shrub utilization. To simplify analysis, we chose to measure twigs during the dormant season on alder, a determinate shrub.

Material and Methods

This sampling test was designed to minimize observer selection of sampling units as a means to reduce variability in twig measurement between observers. It did not deal with the several problems of twig growth during browsing. Ten consecutive alder shrubs (*Alnus incana* (L.) Moench) along 1 side of a stream (McKay Creek) were selected and identified by number. On each shrub, 5 branches located less than 5 feet above ground and distributed around the periphery of the shrub were selected and tagged by letter from A to E. Tags were placed below the fifth twig on each branch (Fig. 1A). Thus, a group of 5 twigs could be identified by shrub and branch. For example, 2B is shrub number 2, branch B. Measurement was limited to those twigs above the tag. Random selection of shrubs and branches was not attempted. The variable under study was differences between observers measuring the same twigs. Each participant was provided with a sampling protocol prior to field measurement. In the field, the protocol was discussed and demonstrated, resulting in some modification.

Fifteen range management professionals independently measured twig lengths. Sampling was conducted in April on McKay Creek, Ochoco National Forest, in central Oregon, while alder shrubs were dormant. This season was selected to eliminate considerations of active twig growth which would add bias to measurements for this test. Instructions called for measurement of the terminal twig first, then the other four twigs in order below it. Forms were provided to standardize data entry for each twig on each branch on each shrub.

Measurements were in whole centimeters using the following instructions: Measure distance between the terminal end of the twig from the base of the bud to the crotch where the twig joins another stem (Fig. 1B). If there is no terminal bud, measure from the base of the most terminal live bud to the crotch. Do not attempt to measure to last year's bud scar (they are difficult to recognize thus adding to observer variability); do not measure dieback portions of the stem; do not measure the main branch past the most terminal crotch; do not measure leaf stubs that are less than 2.4 cm (1 inch) long (Fig. 1C). Record each twig measured.

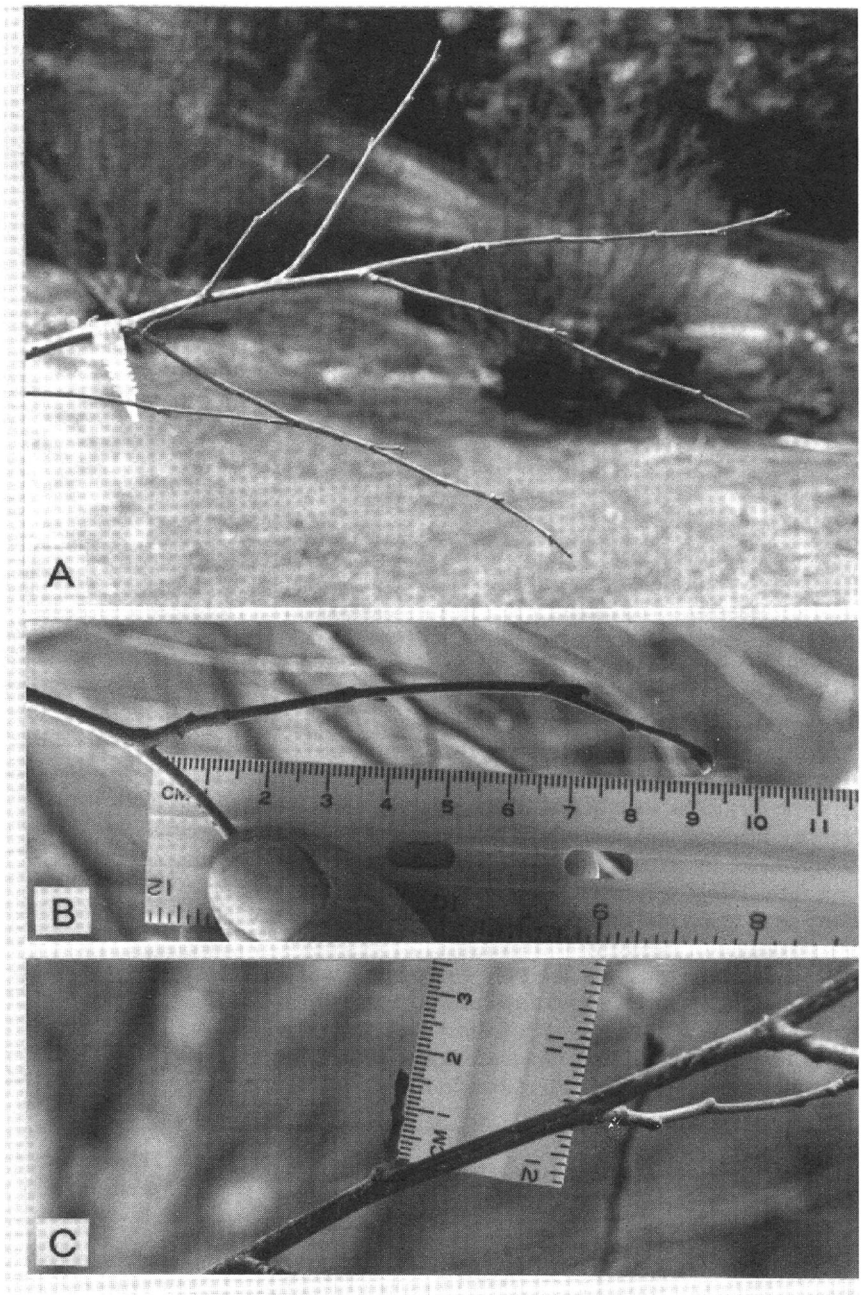

Fig. 1. The ideal sampling situation. A: Shrub 4, branch E, with 5 twigs above the tag. Twigs were measured starting from the terminal and working down the branch. This straightforward branch had an observer coefficient of variation of ± 7 percent. B: Measurement of a twig starting at the crotch and ending at the terminal bud base. C: A leaf stub less than 2.4 cm (1 inch) which would not be measured. Each measurement was recorded and summed for the branch; branches were summed for each shrub.

Data on total length of the 5 twigs measured on each branch were analyzed using a hierarchical analysis of variance (Snedecor and Cochran 1980, chapter 13). The factors analyzed were shrubs, branches within shrubs, and observers' measurement of branches within shrubs. All factors were treated as random effects. The objective of the analysis

was to estimate the variance component associated with each factor. Analysis of variance was completed using SAS, PROC MIXED (Littell et al. 1996) which estimated variance components via the restricted maximum likelihood (REML) method. Confidence intervals for the estimated variance components were also estimated.

Results and Discussion

Statistical analysis

Results of the hierarchical analysis of variance are presented in Table 1. Variability among observers measuring the same total length of 5 twigs per branch was unacceptably large. The variance component for observers was about twice the size of variability among shrubs, and represented 20% of the total variation. Variability among observers is an assessment of measurement error and should be substantially smaller than the other components of variance.

The other 2 components of variance represent 2 distinct components of sampling error. Most statistical methods assume there is no measurement error, so measurement error should be small relative to these components of sampling error. In usual analysis of such data, the measurement error is included, inseparably, with sampling error. For this study, we selected a measurement error of 2% of total variation. This would be substantially smaller than the smallest component of sampling error, i.e. the variance attributable to shrubs. Hence, measurement error would need to be reduced by an order of magnitude, e.g. from 20% to say 2% on a relative scale or from 85 to about 8 on an absolute scale.

Observer Decisions

The statistics presented do not reveal why so much variability occurred among observers. Data analysis and comments on observer field sheets did not provide adequate explanations for major observer variability. Subsequently, the sampling site was revisited to examine shrubs and branches, particularly those with greatest observer variability.

The ideal situation is represented in Figure 1A with a tagged 5-twig branch, Figure 1B showing a clearly defined crotch and bud base, and Figure 1C a typical leaf stub that was not to be measured. Figure 2 illustrates observer choice of what constitutes a crotch to measure from: is the crotch with a dead twig suitable or should one chose a crotch with 2 live twigs? Figure 3 illustrates problems of dieback at the crotch and no bud at a browsed twig end as they relate to measurement. Figure 3 also illustrates branch characteristics of shrubs with greatest observer variability. We must be prepared to deal with previous browsing effects when evaluating riparian shrub utilization.

These concerns may be summarized as follows:

1. Interpretation of dieback and whether it constitutes a crotch (Fig. 2 and 3).
2. Interpretation of live versus dead buds for measurements (Fig. 2 and 3).
3. Interpretation of missing buds–measure to what? (Fig. 2 and 3).
4. Interpretation of what constitutes a crotch to measure from (Fig. 2 and 3).
5. Decisions to include or exclude distal portions of browsed twigs (Fig. 2 and 3).
6. Decisions to measure or not measure twigs less than 2.4 cm long depending upon interpretation of factors referenced in numbers 2 and 3 above (Fig. 2 and 3). If a twig less than 2.4 cm long had been browsed or had no bud, should it be measured? Had it been longer than 2.4 cm?
7. Observers commented that no existing bud or the presence of dieback means no twig growth so that portion of the twig should not be measured; instead measure to the furthest live bud where twig elongation can begin. This means the dieback or stem distance to the missing bud would be considered utilization even though it had not been removed.

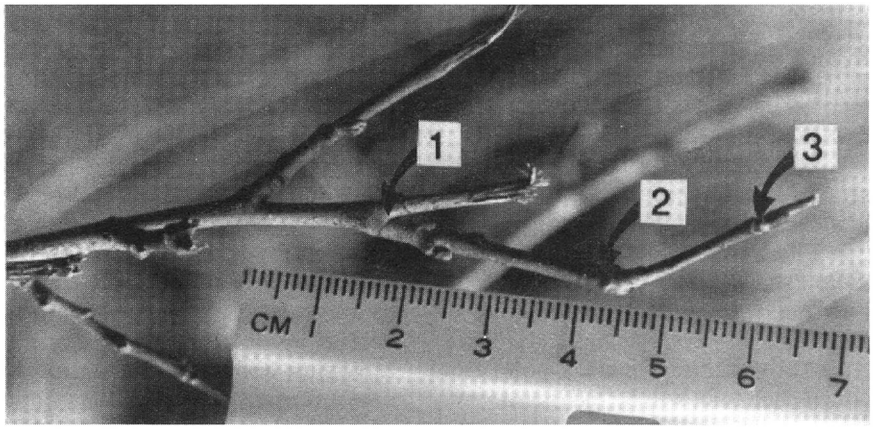

Fig. 2. A multiple browsed alder branch illustrating choices to be made by an observer. At 1, is this a crotch to measure from? The distal portion is dieback and not to be measured. However, if this crotch was used to measure the twig prior to dieback, how does not using it on this sampling affect measurement of utilization? At 2, does the bud here indicate the end of the twig to be measured if the bud at 3 is missing? If so, the distance from bud to end of twig is measured as utilization even though it was not removed. Is the ruler correctly placed for a measurement? Measure to what? All are sources of observer variability.

Table 1. Estimated variance components of each experimental factor, with 95% confidence intervals.

Source of Variation	Estimated variance component	95% confidence limits	Percent of total variation
Among shrubs	48	(11, 6220)	11
Among branches within shrub	302	(200, 505)	69
Among observers within branch	85	(77, 95)	20
Total	435		100

Recommendations and Conclusions

This test suggests that observer selection of what to measure on browsed twigs precludes efficient determination of twig length. Without efficient twig length measurement, we can not quantitatively determine riparian shrub utiliza-

tion which requires 2 measurements, before and after use. If one must determine twig length, a clearly defined protocol is essential. The following procedure is suggested:

1. Permanently (for the duration of the study) tag and identify shrubs and branches to be sampled.
2. Place tags below at least 5 and no more than 10 twigs; do not try to specify how many twigs to include above the tag.
3. Above the tag, mark a point from which each twig will be measured.
4. Clearly define and illustrate with pictures:
   A. The attachment of the twig to a branch: what constitutes a crotch?
   B. The terminal end of the twig considering bud or no bud and dieback.
   C. How to deal with dieback.
   D. How to deal with leaf stubs.
5. Train observers in the sampling system, identification of what to measure, how to measure it, and in data collection and recording.

Several additional critical questions essential in appraising riparian shrub use were not addressed in this study. Examples are: 1) how to select seasons to measure, 2) how does season-long active stem elongation during the browsing and sampling period affect measurement? 3) how does apparent stimulated growth of lateral twigs as they become terminals after removal of the terminal bud affect measurements? 4) how are animals browsing, including wild ungulates and bud nipping birds such as grosbeaks, interpreted when the objective is livestock management? and 5) what protocol and data forms are required to document and interpret measured utilization?

This study and the above elements lead us to seriously question the feasibility of measuring riparian shrub utilization for the following reasons: 1) observer interpretation of what and how to measure twig length results in serious between-observer variability, 2) twig growth for many riparian shrubs continues throughout the grazing or browsing season seriously compromising interpretation of before-and-after measurements, 3) is percent utilization a critical factor or is simply an increase in shrub cover a primary objective? and 4) do the results of a half day sampling by a 2-person team warrent the effort or could their time be better spent in other activities such as photo monitoring? We feel that measurement of riparian shrub utilization does not warrent the effort.

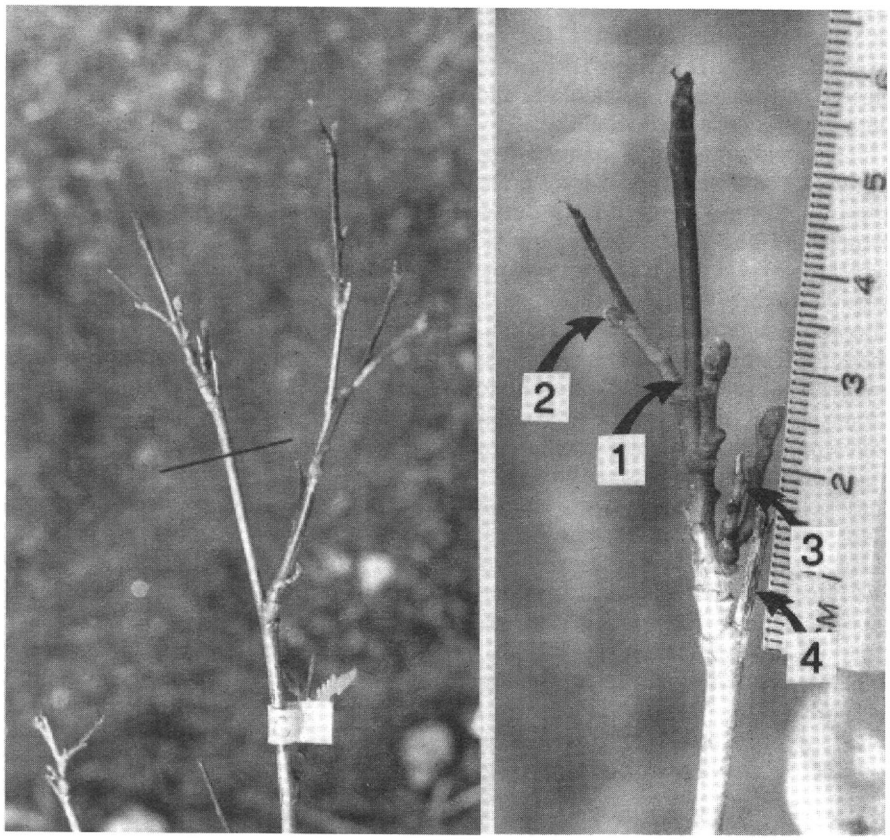

Fig. 3. Shrub 2, branch C with an observer coefficient of variation of 22% illustrating the reason for high observer variability. The portion of twig marked is shown close-up on the right. Dieback has occurred on the main stem to arrow 1. If it is not measured, it would be included in twig length utilized. On the left twig, dieback has occurred to a live bud at arrow 2. Was the twig longer than 2.4 cm? Should it be measured now? How does it contribute to determining utilization? Two short twigs are dead noted by arrows 3 and 4. If they had been measured previously, the remaining twigs would be part of utilization. Should the short stub next to the ruler, only 1.5 cm long, be measured? Is it a leaf stub depicted in Figure 1? An observer must decide what is a crotch to measure from, what to measure to, and what stems to measure. All are reasons for variability between observers.

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