Bitterlich's Plotless Method for Sampling Basal Ground Cover of Bunchgrasses[1]

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Bitterlich's plotless method was introduced to American foresters by Grosenbaugh (1952). Grosenbaugh provided a comprehensive description of the method, and a number of authors have subsequently discussed new instrumentation and field applications. Cooper (1957) has recently shown how the method may be used to sample shrub cover directly in percentage of ground surface covered.

The principle is that in a theoretical circular plot drawn around each plant, the area ratio of plant: plot is constant. For instance, with a plant: plot area ratio of 1:100 the plants are always 1 percent of the plot areas. Then the number of plots overlapping a given point may be counted and expressed directly as plant-cover percentage.

With a plant: plot area ratio of 1:100, the corresponding radius ratio of 2 circles is 1:10. The radius ratio of 1:10 describes an angle of 11°29′. That is, the angle will just include a small circle having a radius 1/10 as long as the distance of its center from the vertex of the angle. Thus, ground cover may be estimated by counting those plants that fill the angle when the vertex is fixed at a selected sample point. It is well to emphasize that the sample is a point, and that the objective is to count the theoretical plots which overlap at the point. The angle serves that objective because each plant that fills the angle has a plot that overlaps (includes) the sample point.

This paper presents an instrumentation of Bitterlich's plotless method for sampling basal ground cover of bunchgrasses, and compares results obtained by this method with results obtained by line interception (Canfield, 1941).

Procedure

Application of Bitterlich's plotless method requires an angle which is rotated in a complete circle about a selected sampling point as an observer views the vegetation. Consequently, an acute angle (described by the plant: plot radius ratio of 1:10 was prepared by welding 1½-inch angle iron (Figure 1). The arms extended about 4 feet, and further extension of the angle was accomplished with a straightedge when viewing large grass clumps beyond reach of the frame. A ¼-inch hole drilled at the vertex of the angle permitted pinning to selected sampling points.

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FIGURE 1. An acute angle was prepared by welding 1½-inch angle iron and drilling a ¼-inch hole at the vertex.

Eight 100-foot transects were established on sagebrush-bunchgrass range which had previously been sprayed with 2,4-D for sagebrush control. The area had been grazed moderately prior to sampling in September 1958.

When measuring basal ground cover by the line interception method, the interception of bunchgrass crowns directly below the edge of the tape was measured to the nearest 0.01 foot and recorded by species. When sampling with the angle, 10 points were established at 10-foot intervals along the tape beginning 5 feet from the origin. At each point the angle was pinned and rotated about the full circle while the observer counted all clumps of grass by species, which filled the angle at ground level. Each count gave one percent cover. Basal ground cover data were recorded separately for each sampling point. It should be observed that plants appearing to exactly fill the angle should be counted only half the time because there is insufficient precision to determine whether the respective plots just include or exclude the sample point.

Two observers read each transect by each method in random order without preliminary practice; however, each observer had considerable previous experience with line interception. An assistant was employed by each observer for recording data and reading time.

Transects, methods, and observers were compared in terms of percentage basal ground cover, number of individual plants sampled, number of species sampled, and minutes of reading time by standard anayses of variance.

Results

Mean squares for relating variance to difference among transects, between methods, and between observers are presented in Table 1. Methods alone introduced significant variance in basal ground cover, number of plants encountered, and number of species encountered. However, reading time varied significantly among transects, between methods, and between observers.

Basal ground cover estimates with the angle were 40 percent higher than those obtained by line interception (Table 2). However, the difference between methods was not consistent among species (Table 3). By average, species dominance was in the same order for each method. However, the order of dominance between the 2 most abundant species was different between observers when measured by line interception. Differences among species were smaller and the order of dominance was less consistent by line interception.

The angle sample (10 points) included 70 percent more individual plants and 13 percent more species per transect than that obtained by line interception. However, it must be noted that the number of plants included in the angle samples were not measures of frequency of occurrence. Rather, individual species were counted in direct proportion to their dominance in basal ground cover. Frequency of occurrence and average interception length by species, as may be computed from line interception data, provide advantages for this method over Bitterlich's plotless method. The apparent advantage of more plants and species encountered with the angle is a relative indication of sampling intensity that could reverse between methods with equivalent sampling intensities.

Average reading times were 10.6 and 18.5 minutes per transect respectively for 100 feet of line interception and 10 points with the angle (Table 2). However, when reading times by methods were compared at equal sampling intensities, the plotless method required 1/9 as much reading time (Table 4). The number of observations required for an adequate sample of ground cover was estimated to be 44, 100-foot lines of interception and 28 points with the angle.

Table 1. Mean squares for relating variance to transects, methods, and observers.

Source of variation	Degrees of freedom	Variance among sources in terms of: Basal ground cover	Number of plants	Number of species	Reading time
Transects	7	2.6	142	0.4	15.4*
(M)ethods	1	55.7**	10,841**	4.0**	504. **
(O)bservers	1	1.8	75	0.0	294. **
M x O	1	0.1	0	1.0	4.0
Error	21	1.6	113	0.5	4.4

* Significant at the 5-percent probability level.
** Significant at the 1-percent probability level.

Table 2. Mean transect values comparing line interception with Bitterlich's plotless method.*

Sampling methods	Transect measures: Percent ground cover	Number of plants	Number of species	Minutes of reading time
Line interception	6.3	52	5.2	10.6
Bitterlich's plotless method	8.9	89	5.9	18.5
5% L.S.D.	0.9	8	0.5	1.5

*A transect with line interception was 100 feet long and with Bitterlich's method was 10 points at regular intervals along the line.

Consequently, a single point with the angle provided more consistent information regarding total ground cover than did 100 feet of line interception.

A single point with the angle included an average of just 3.4 species. Samples of 2, 3, 4, and 5 points per transect drawn from the data included an average of 4.2, 4.7, 5.0, and 5.2 separate species, respectively. Thus, 5 points per transect recorded as many species as 100 feet of line interception. Five points per transect may be recommended, as this would (theoretically) record each species providing a basal ground cover of 0.2 percent or more. Only 5 species were so abundant in the present data. With 5 points per transect an adequate sample included 6 transects per macro-plot under the conditions studied.

Discussion and Conclusions

Bitterlich's plotless method gave a surprisingly large time advantage over line interception and is worthy of further consideration. The saving in time, however, must be weighed against losses of information on frequency of occurrence among species and average clump size by species, which may be computed from line interception data.

It is of interest to give further consideration to the higher ground-cover estimate obtained with the angle. A comparison of methods by individual species indicated considerable disparity. Consider, for instance, the 3 most abundant species presented in Table 3. The ground-cover estimates for *A. spicatum* and *K. cristata* were much higher with the angle than with line interception. However, the ground-cover estimates for *P. secunda* were essentially equal. This disparity may have been because of clump size, shape, and stem density within the clumps. The assumption of circular plants is realistic for tree d.b.h., but is less realistic for clumps of grass. *P. secunda* grew in small round clumps, but *K. cristata* and especially *A. spicatum* often formed large clumps having dead portions and irregular shapes. In line interception dead portions and irregular contours often caused interruption in measurements, which in turn created disparity in the consideration of the number of individuals of each species intercepted (frequency of occurrence). With the angle it would be difficult to establish rules for omitting dead portions of clumps or for reconciling irregular shapes. In the present study all continuous clumps of grass that filled the angle were counted without adjustment. Perhaps this disparity would constitute a problem in some investigations. Cooper (1957) presented similar disparities among shrub species; however, his data were not interpreted in terms of qualitative differences between methods. In his data the plotless method gave estimates that were 102, 140, and 107 percent as much as line interception, respectively, for creosote bush, palo verde, and burroweed.

The authors believe that it is expedient to employ an assistant to record data obtained by line interception, but that an assistant is unnecessary when the angle is used. Assistants were employed with each method in the present study. Although we cannot expand the implication of this opinion regarding the importance of an assistant, it is well to note that the recording and compilation of data obtained with the angle was simple and fast. In consequence, other workers using the angle might obtain even greater time advantage than is reported.

Since it is a common practice to stratify large areas and choose by restricted randomization the locations for macroplots (which are subsequently sampled thoroughly), it is presumed that the time-advantage reported would be generally applicable. However, under the sampling conditions selected for the present study, there was only slight interference by sagebrush. The time advantage would probably have been much less if sampling had been conducted under a sagebrush overstory because the angle frame employed was cumbersome when brush was encountered.

Summary

Bitterlich's plotless method was tested as a method for sampling basal ground cover of bunchgrasses. A suitable acute angle (described by the plant: plot radius ratio of 1:10) was prepared by welding 1½-inch angle iron and drilling a ¼-inch hole at the vertex of the angle for pinning to selected sampling points. Basal ground cover about a point was determined by counting each plant that filled the angle. Each count gave 1 percent in basal ground cover.

Sample data obtained with the angle were compared with line

Table 3. Species dominance in basal ground cover by line interception and Bitterlich's plotless method.

Species	Percent basal ground cover by: Line interception A[a]	B	Average	Bitterlich's plotless method A	B	Average
Agropyron spicatum	2.0	2.3	2.2	3.6	3.4	3.5
Koeleria cristata	2.5	1.7	2.1	3.2	2.9	3.0
Poa secunda	1.4	1.2	1.3	1.2	1.2	1.2
Stipa thurberiana	0.5	0.4	0.4	0.5	0.6	0.6
Festuca idahoensis	0.1	0.2	0.2	0.5	0.5	0.5
Sitanion hystrix	0.1	0.1	0.1	0.1	0.1	0.1
Oryzopsis hymenoides	t[b]		t	t	t	t
Elymus cinereus				t		t

[a]Capital letters A and B identify observers.
[b]Trace.

interception data. When the methods were compared at equivalent sampling intensities, the angle required 1/9 as much time as line interception. Basal ground-cover estimates were 40 percent higher, differences among species were larger, and the order of species dominance was more consistent with the angle than with line interception.

Table 4. Average number of samples and relative time required to obtain equal intensity in sampling[a] with line interception and Bitterlich's plotless method.

Sampling method	Observer	Number of samples[b]	Reading time: Minutes/sample	Total
Line interception (100 feet per sample)	A	44	13.2	586
	B	43	7.9	340
	Average	44	10.6	464
Bitterlich's plotless method (one point per sample)	A	22	2.2	48
	B	34	1.5	51
	Average	28	1.8	50

[a]Sample in which the variance is 10 percent of mean basal ground cover at the 5 percent level of probability.
[b]Estimated from $N = t^2s^2/(\bar{x}-m)^2$.

The assumption of circular plants is realistic for tree d.b.h., but is less so for clumps of grass. Ground-cover estimates for species growing in large irregular-shaped clumps were higher with the angle than with line interception; however, estimates for species growing in small, round clumps were essentially the same with each method. Perhaps this disparity would constitute a problem in some investigations.

The authors believe that it is expedient to employ an assistant to record data obtained by line interception but that an assistant is unnecessary when the angle is used.

The time advantage would probably have been much less if sampling had been conducted under sagebrush overstory, because the angle frame employed was cumbersome when brush was encountered.

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