A Comparison of the Line-interception and Quadrat Estimation Methods of Determining Shrub Canopy Coverage

THOMAS A. HANLEY

Highlight: The line-interception and Daubenmire's 0.1 m² quadrat estimation methods of determining canopy coverage were compared for four densities of big sagebrush in northwestern Nevada. Results indicated that the methods provide comparable estimates. The line-interception method is preferable to 0.1 m² quadrats where high levels of precision and confidence are required, but the 0.1 m² quadrat method may be preferable where lower levels of precision and confidence are acceptable. Fewer man-minutes of time are required by either method for one person working alone than for two people working together.

Canopy coverage is a frequently measured and useful parameter in range analysis. It serves as a criterion of relative dominance and the influence of plants on precipitation interception and soil temperature. Compared with other parameters, such as biomass or productivity, canopy coverage is relatively easily measured. Evaluations precise enough for research purposes generally do not require excessive field time.

A variety of methods have been devised for measuring plant canopy coverage, but advantages and disadvantages vary with types of vegetation sampled and degrees of confidence and precision[1] required. The line-interception method (Canfield 1941) is a frequently used technique for measuring canopy coverage of shrubs in the Great Basin. Kinsinger et al. (1960) compared results of line-interception, variable plot, and loop methods for shrub cover in Nevada and found the line-interception method to be the most accurate. However, it required an undesirably large sample size due to the variability between sample units (lines). Daubenmire (1959) compared results of the line-interception method and an estimation technique using 0.1 m² quadrat sampling for big sagebrush (*Artemisia tridentata*) and found that although the standard error of 0.1 m² quadrat sampling was high, the estimates obtained from 40–50 quadrats were nearly identical to those from 350 m of line-interception. He pointed out that much more time was required for the line-interception method than for the quadrats.

Quadrat sampling of canopy coverage usually involves a visual estimation of canopy coverage within a circular or rectangular plot, whereas the line-interception method involves measurement of the intercepted lengths of an "elongated plot without width." Advantages of quadrat sampling over linear and plotless techniques have been elaborated by Daubenmire (1959) and include (1) enhanced opportunity for comparison and correlation of more taxa, (2) evaluation of frequency, and (3) more complete information about the community as a whole. The principal advantage of the line-interception technique is that of direct measurement, as opposed to visual estimation, of the vegetation being sampled (Canfield 1941).

It was the purpose of this study to compare the precision and efficiency of the line-interception (Canfield 1941) and 0.1 m² quadrat estimation (Daubenmire 1959) methods for measuring Great Basin shrub canopy coverage in varying stands of shrub canopy cover. Canopy coverage, as used in this study, was defined as the percentage of the ground included in a vertical projection of imaginary polygons drawn about the total natural spread of foliage of the individuals of a species (Daubenmire (1968). Dead portions of the canopy were not included.

Methods

Four sites were selected for study. All were in northwestern Nevada, near Cedarville, California. Big sagebrush was the sole shrub component in three of the sites. Minor amounts of shadscale (*Atriplex confertifolia*) and greasewood (*Sarcobatus vermiculatus*) were present in the site with the lowest total cover. Big sagebrush canopy coverage ranged from approximately 8–48% over the four sites. The average shrub height was approximately 75 cm at each site.

Ten parallel 30-m lines, systematically spaced at 3-meter intervals, were used for the line-interception method. Forty 0.1 m² (20 × 50 cm) quadrats, systematically spaced at 1.5-m intervals along two parallel 30-m lines 3 meters apart, were used for the quadrat method: canopy coverage was estimated within six cover classes: (1) 0–5, (2) 5–25, (3) 25–50, (4) 50–75, (5) 75–95, and (6) 95–100%, with the midpoints of each class used in computing the mean. Such classes are believed to leave little chance for personal error in class assignments, yet yield rather fine differences when the results from a considerable number of small plots are averaged (Daubenmire 1959). Each site was sampled by both methods twice, once with one person working alone and once with two people working together. All measurements and estimates were made by the same person. The time required for each method was recorded each time. Thus, data from a total of 600 m of line-interception and 80 0.1 m² quadrats were obtained at each site sampled. The person conducting the

The author is wildlife biologist, U.S. Department of the Interior, Bureau of Land Management, Cedarville, California 96104. His present address is, College of Forest Resources, AR-10, University of Washington, Seattle 98195.

The author is grateful to Kathleen A. Hanley for her assistance with the field data collection.

Manuscript received May 23, 1977.

[1] As used in this report, the term *precision* refers to the size of deviations from the mean obtained by applying the sampling procedure repeatedly; the term *confidence* refers to the level of probability that the sample size will provide an estimate within a given precision.

sampling was already familiar with the use of both techniques. Therefore, data were not available concerning the amount of time necessary for training the observer; nor were data available concerning differences between individual observers.

Canopy coverage data were analyzed in a 4 × 2 × 2 factorial. The layout was a randomized complete-block design with each datum being the mean canopy coverage of ten lines or 40 quadrats. Blocks were sites, and factors were sampling methods and number of persons. An arcsine transformation ($\arcsin\sqrt{x}$) was used, because percentage or proportion data usually fit a binomial distribution (Steel and Torrie 1960; Zar 1974).

Results and Discussion

Highly significant (α = 0.001) differences were found between mean cover of sites, as was expected. No significant ($\alpha = 0.05$) differences were found between means of the two methods, the number of persons, or any interactions. Therefore, the line-interception and 0.1 m^2 quadrat methods, whether conducted by one person alone or two people together, yielded comparable results over the entire range of shrub canopy coverage sampled.

The data for the number of persons were pooled by method, and the sample size (number of lines or quadrats) and time required for one and two people to sample within two levels of precision and confidence were calculated (Table 1) using the pooled sample variances as estimates of the true population variances. Due to the greater variability between samples at low shrub density, much larger sample sizes would be required by both methods when the total canopy coverage approaches 10% than when it approaches 50%. The size of line-interception samples required are comparable to those reported by Kinsinger et al. (1960). In all cases the time required to sample within these levels of precision and confidence would be less for the line-interception method than for the 0.1 m^2 quadrat method. Two people working together would require more man-minutes of time than would one person working alone in most cases for either method. However, the numbers of samples, and consequently the time, required to sample within these levels of precision and confidence are undesirably high for both methods.

Daubenmire (1959) suggested that in such comparisons adequate sample

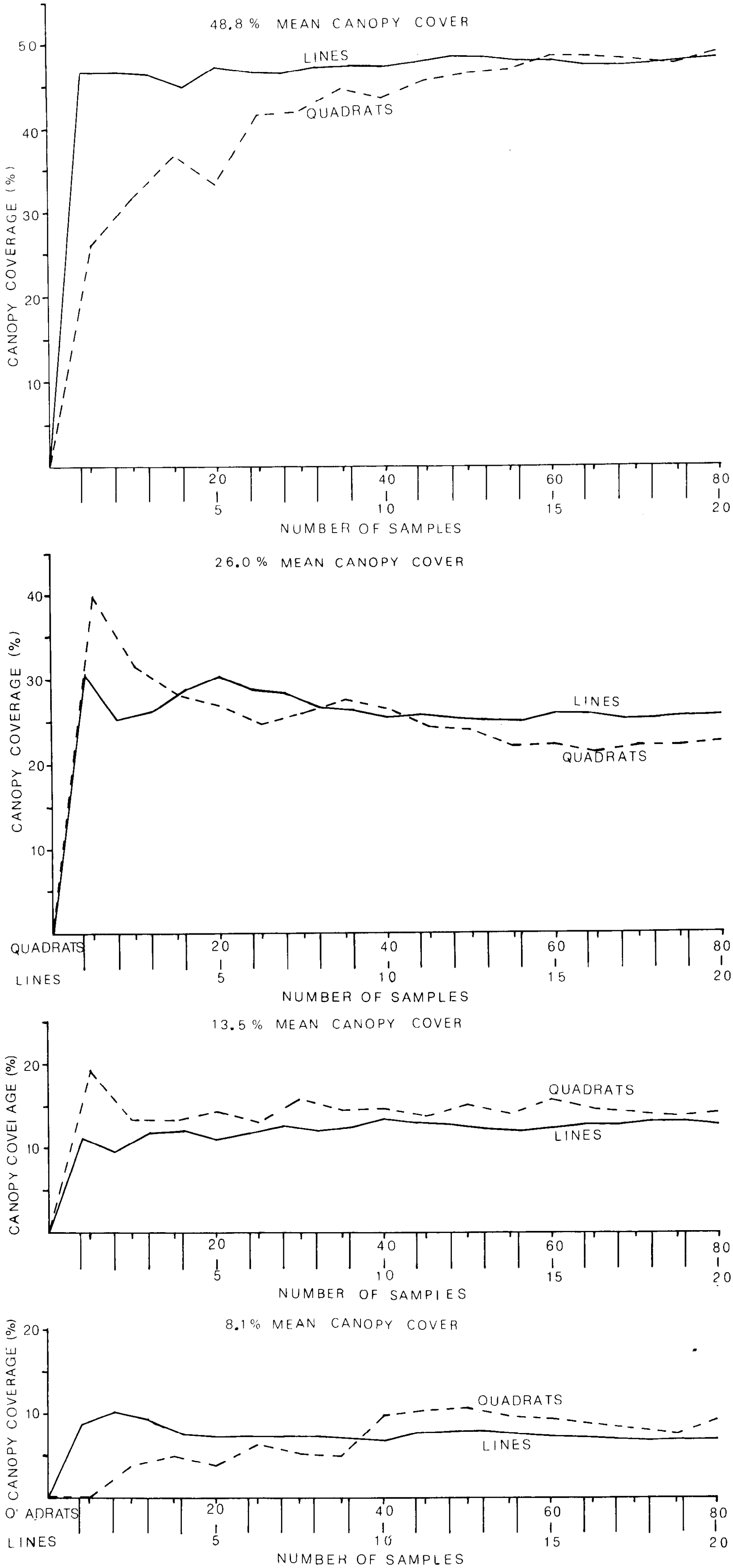

Fig. 1. *Change in mean canopy coverage with increasing sample size.*

Table 1. Comparison of mean ($\bar{x}$) big sagebrush canopy coverage, size of sample required (n), and man-minutes required for one person alone (t_1) and two people together (t_2) to sample within two levels of precision and two levels of confidence using the 0.1 m² quadrat and line-interception methods.

Cover at different locations	Within ± 0.10x̄ and 0.95 confidence level: Quadrats (0.1 m²)	Within ± 0.10x̄ and 0.95 confidence level: Line-interception (30 m)	Within ± 0.20x̄ and 0.90 confidence level: Quadrats (0.1 m²)	Within ± 0.20x̄ and 0.90 confidence level: Line-interception (30 m)
8.1% mean cover	$\bar{x}$ = 9.19% n = 2700 t_1 = 675 t_2 = 1080	$\bar{x}$ = 6.92% n = 115 t_1 = 380 t_2 = 368	$\bar{x}$ = 9.19% n = 471 t_1 = 118 t_2 = 190	$\bar{x}$ = 6.92% n = 19 t_1 = 63 t_2 = 62
13.5% mean cover	$\bar{x}$ = 14.31% n = 1261 t_1 = 316 t_2 = 380	$\bar{x}$ = 12.75% n = 80 t_1 = 288 t_2 = 288	$\bar{x}$ = 14.31% n = 221 t_1 = 56 t_2 = 68	$\bar{x}$ = 12.75% n = 14 t_1 = 51 t_2 = 52
26.0% mean cover	$\bar{x}$ = 26.44% n = 551 t_1 = 193 t_2 = 248	$\bar{x}$ = 25.48% n = 36 t_1 = 173 t_2 = 196	$\bar{x}$ = 26.44% n = 97 t_1 = 34 t_2 = 44	$\bar{x}$ = 25.48% n = 6 t_1 = 29 t_2 = 34
48.4% mean cover	$\bar{x}$ = 48.56% n = 223 t_1 = 84 t_2 = 112	$\bar{x}$ = 48.17% n = 6 t_1 = 37 t_2 = 36	$\bar{x}$ = 48.56% n = 39 t_1 = 15 t_2 = 20	$\bar{x}$ = 48.17% n = 1 t_1 = 7 t_2 = 6

Table 2. Comparison of time (minutes) required for one person to sample ten 30-m line-interception transects versus 80 0.1 m² quadrats for big sagebrush canopy coverage.

Mean canopy coverage	10 lines	80 quadrats
8.1%	33	20
13.5%	36	20
26.0%	48	28
48.4%	61	30

sizes calculated on the basis of the standard error overestimate the amount of work needed to obtain a reasonable appraisal of the coverage of scattered shrubs. If this is true, then both methods may be of more practical value to range ecologists. The methods were therefore compared by a graphical procedure of plotting their means as cumulative functions of increasing sample size (Fig. 1). In each case, the line-interception mean appeared to stabilize earlier than the quadrat mean. The need for larger sample sizes at lower shrub densities appeared to hold true, especially for the 0.1 m² quadrat method. However, the argument that sample sizes greater than those involved in this study (20 30-m line-interception transects and 80 0.1 m² quadrats) are not needed to obtain a reasonable appraisal of big sagebrush canopy coverage appears to be plausible, especially for the line-interception method. A comparison of the time required for one person to sample ten 30-m line-interception transects versus 80 0.1 m² quadrats (Table 2) shows that comparable results may be obtained by the 0.1 m² quadrat method in slightly more than one-half the time required for the line-interception method.

These data and analyses therefore indicate that the line-interception and 0.1 m² quadrat methods are equivalent in accuracy of measuring canopy coverage of big sagebrush, but that the sample size and time required for adequate sampling affect the relative advantages and disadvantages of each in relation to the sampling objectives. Where a high degree of precision and confidence are required (where repeatability is very important), the line-interception method would be more advantageous than the 0.1 m² quadrat method; however, both methods would be very time consuming. Where a lower level of precision and confidence are acceptable (e.g., as in range inventories), the 0.1 m² quadrat method may be more advantageous than the line-interception method. In either case, no time (man-minutes) is saved by two people working together rather than one person working alone.

These conclusions are expected to be true for the range of shrub canopy coverage analyzed. The inverse relationship between adequate sample size and canopy coverage may be especially important for species with lower canopy coverage than that investigated in this study.

Literature Cited

Canfield, R. H. 1941. Application of the line-interception method in sampling range vegetation. J. Forest. 39:388-394.

Daubenmire, R. 1959. A canopy-coverage method of vegetational analysis. Northwest Sci. 33:43-64.

Daubenmire, R. 1968. Plant communities: a textbook in plant synecology. Harper & Row, New York. 300 p.

Kinsinger, F. E., R. E. Eckert, and P. O. Currie. 1960. A comparison of the line-interception, variable plot and loop methods as used to measure shrub-crown cover. J. Range Manage. 13:17-21.

Steel, R. G. D., and J. H. Torrie. 1960. Principles and procedures of statistics. McGraw-Hill Book Co., Inc., New York. 481 p.

Zar, J. H. 1974. Biostatistical analysis. Prentice-Hall, Inc., Englewood Cliffs, N.J. 620 p.