Relationships of the Error Associated with Ocular Estimation and Actual Total Cover

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Abstract

The relationship between the error associated with the ocular estimation of cover and the magnitude of actual cover was examined by estimation of artificially constructed images of known cover under laboratory conditions. Estimation error varied with actual cover in a manner suggesting that cover classes should be relatively narrow at the extremes of actual cover.

Ocular estimation of plant cover is a fundamental and widely employed method for the evaluation of plant dominance, succession and treatment response in vegetation studies. Relationships between error incurred with such estimates and the magnitude of percent cover are, however, lacking in the literature. While this function may be largely circumvented by the use of estimation classes (Daubenmire 1959, Braun-Blanquet 1965, Domin and Krajina (in Mueller-Dombois and Ellenberg 1974)), the width and distribution of these classes has been intuitive. The purpose of this investigation was to better define the relationship between actual percent cover and the error associated with ocular estimation.

The ocular estimation of plant cover is complicated by the great variety of life forms, surface contrasts, and canopy relationships. It is unrealistic to examine estimation of error over an infinite combination of these variables. In addition, the parametric values for cover in natural populations is seldom known and is often unstable. Rather, this study focused upon the basic relationship between error and cover, controlling for the aforementioned factors through the use of an artificial population of two-dimensional images of known coverage. The implicit compromises that this approach entails are the restrictions of no overlap and nonrandomness at the edge of field (Schultz et al. 1961). By taking this approach, however, we may interpret our findings in terms of a "best case" situation, upon which future investigations dealing with more complex situations may build.

Materials and Methods

The artificial population used in this study consisted of 20 two-dimensional images of known coverage. The images consisted of irregular, entire, light-green colored paper figures mounted with varying degrees of aggregation on white posterboard, arranged to avoid any overlap among the figures or with a round 0.25-meters square quadrat boundary. The choice of quadrat size and shape, as well as image color, was largely arbitrary and these factors were held constant. Paper figures for any one image were cut out of a single sheet of paper of known area in a complex, jigsaw fashion. The coverage of these images ranged from 0.36 to 97.30%; actual cover percentages of the artificial images were designed to cover this range at roughly equivalent intervals. At 4 actual coverage levels, 2 replicates were constructed with the same percent cover but with unique configurations and degrees of aggregation.

Twenty-four graduate students and faculty of the Utah State University College of Natural Resources estimated total percent cover for the 20 quadrats under laboratory conditions. All participants were instructed to make their estimates at the highest degree of precision possible, based on actual total cover; that is, only the area covered by the figures themselves, as opposed to the polygon method of Daubenmire (1959).

The standard error of estimate and coefficient of variation were calculated for the mean of observer estimates for each quadrat. Least squares second order polynomial regressions were derived to estimate the strength of the relationship between error and the magnitude of actual cover.

Results and Discussion

Table 1 shows the actual cover values along with the corresponding means of 24 observer estimates and the standard errors of those mean estimates. The least squares linear regression line for actual cover *(X)* versus mean estimated cover *(Y)* is:

$$Y = -0.33 + 1.00(X)$$

The coefficient of determination (r^2) for this equation is 0.99 ($p<0.001$) and the y-intercept is not significant ($p>0.1$).

Table 1. Actual cover, mean estimated cover, and the standard error of mean estimated cover for twenty two-dimensional, artificial paper images.

Actual cover (%)	Mean estimated cover (%)	Standard error of mean estimates (%)
0.36	0.83	0.11
1.45	2.30	0.26
2.32	3.02	0.39
5.79	6.10	0.61
11.58	11.63	0.75
11.58	10.83	0.78
23.17	24.12	1.18
30.12	29.13	0.60
34.75	33.42	1.36
34.75	33.42	1.81
40.55	38.79	1.15
46.34	44.63	1.56
52.13	51.75	1.54
52.13	51.21	1.02
57.92	58.29	1.39
57.92	55.08	1.82
63.72	63.83	1.51
81.09	81.63	1.48
86.89	89.92	0.98
97.31	97.54	0.27

Figure 1 shows the relationship between the coefficient of variation and actual cover. The least squares polynomial function produced an r^2 of 0.85 ($p<0.001$). Error expressed as a function of the mean declined rapidly to about 40% actual cover, and more slowly thereafter. Note that the curve does not extend to the limits of actual cover.

Figure 2 shows the relationship between the standard error of estimate and actual cover. The least squares polynomial function produced an r^2 of 0.75 ($p<0.001$). The magnitude of the standard error peaked at approximately 55% actual cover, and declined in a roughly symmetric fashion with increasing or decreasing actual cover. Again note that the curve does not extend to the limits of actual cover.

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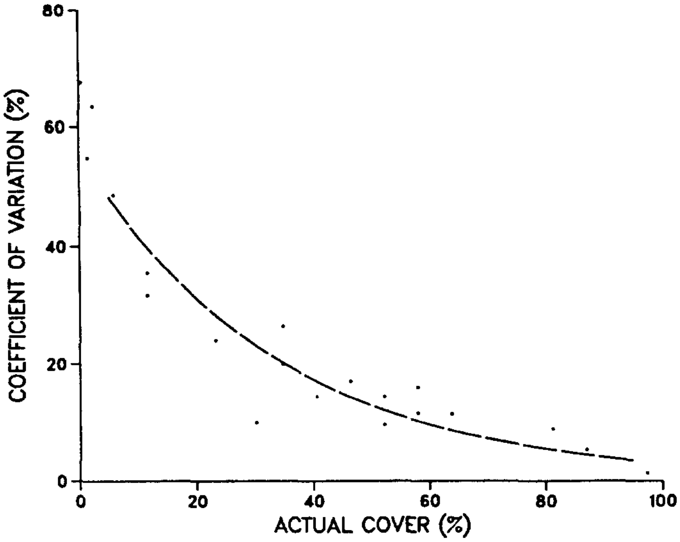

Fig. 1. *The relationship between the coefficient of variation for mean estimated cover and actual cover of a two-dimensional population of artificial paper images.*

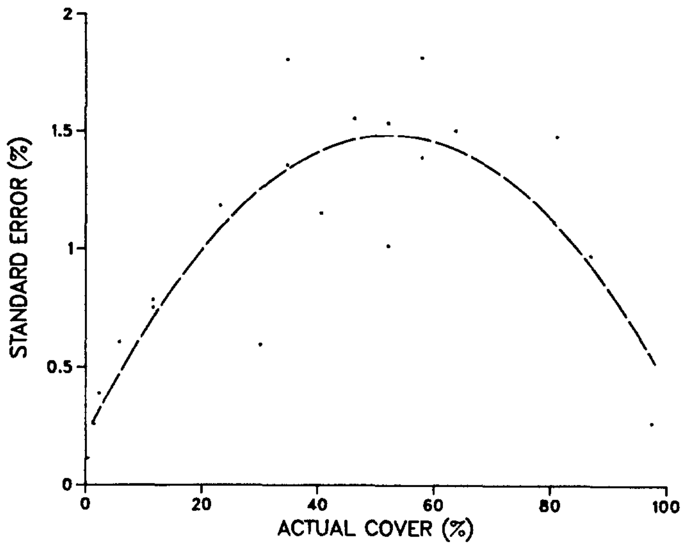

Fig. 2. *The relationship between the standard error of mean cover estimations and the actual cover of a two-dimensional population of artificial paper images.*

The standard deviation expressed as a percentage of the mean, or coefficient of variation, increases rapidly below 40% cover, reflecting the limits of precision of the observers. For example, if the average observer cannot estimate cover to a precision less than 0.5%, then this will have much less effect on the coefficient of variation at 50% actual cover than at 1% actual cover. The behavior of this relationship at the limits of actual cover is not entirely clear. Presumably, an observer under these conditions should be able to perfectly estimate zero and 100% actual cover, and thus the coefficient of variation should go to zero at these limits. At the upper limit, this seems to agree with our empirically-determined relationship. As one approaches zero, however, the coefficient of variation approaches the value 0/0, and is thus mathematically unstable. Though it is unlikely that this would ever be of any practical concern in field ecology, the theoretical behavior at this limit remains unclear.

When error is expressed as the standard error of the mean, which carries the same units as the original value (in this case, percent cover), we find a slightly skewed-left parabolic curve, with a peak error at approximately 55% actual cover. This suggests that extremes of cover may be estimated with less error than intermediate cover levels (the fitted curve does not extend to the limits of actual cover because these extremes were not empirically tested, though in theory the standard error of estimate should go to zero at zero and 100% actual cover). On this basis, cover estimation classes should ideally be relatively narrow at the extremes and wider for the intermediate ranges of cover. The Daubenmire (1959) cover classes (0–5, 5–25, 25–50, 50–75, 75–95, and 95–100%) reflect this near-symmetrical decrease in observer error at the extremes of actual cover. A modification of this scale by Bailey and Poulton (1968) separates the 0–5% cover class into two classes (0–1 and 1–5%), and perhaps better reflects the slightly skewed-left nature of our empirical curve. The Domin-Krajina (in Mueller-Dombois and Ellenberg 1974) scale (<1, 1–5, 5–10, 10–25, 25–33, 33–50, 50–75, 75–95 and 95–100%) has narrower cover classes at the extremes, but is more skewed-left than the standard error curve based on our empirical data. The Braun-Blanquet (1965) (<1, 1–5, 5–25, 25–50, 50–75, and >75%) is asymmetric, lacking a narrow cover class at the upper end of the scale.

The actual ability of observers to estimate cover will, of course, vary under the complicated conditions encountered in the field. This study focused on total cover, and controlled for canopy overlap and height, as well as for edge effects. Such complications may be expected to increase observer error at any given level of actual cover, though we expect the relationships found in this study to hold, at least in a relative way, over the range of cover values. The artificial population used in this study did vary in the degree of aggregation of the paper figure, and is thus more extensible to field situations than a population with random distributions of figures (Schultz et al. 1961).

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