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SAMPLING EFFORT AND VEGETATIVE COVER ESTIMATES IN SAGEBRUSH STEPPE

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ABSTRACT.—The goal of this study was to identify relationships between sampling effort, using a point frame, and the precision of estimates of vegetative cover in sagebrush steppe. Data for 208 point-frame samples were randomly drawn and 95% confidence intervals were identified for varying sample sizes of individual species and species groups. Confidence interval widths decreased rapidly as sample sizes increased from 1 to 50, and more slowly as sample sizes were increased further. For the more abundant species, sample sizes of fewer than 50 frames were sufficient to reduce the 95% confidence interval to less than one-half of average cover. For species with average cover less than 5%, the sample size required to achieve the same relative confidence was much larger. Analyses were repeated to compare point frames with 36 versus 50 sample points per frame. Using a point frame with 50 sample points decreased the number of frames required to achieve the same level of confidence; however, the reduction in sample size was less than the 28% reduction in sample points per frame. Because of the time required to establish transects and position the point frame, it may still be worth sampling more points per frame.

Key words: sagebrush steppe, point frame, vegetative cover, sampling effort.

Methods commonly used to estimate vegetative cover include line interception (Canfield 1941, Lucas and Seber 1977, DeVries 1979), visual estimation of cover classes (Daubenmire 1959), and point interception (Floyd and Anderson 1987). The method that is most precise, giving the most accurate measure of cover, and the method that is most efficient, providing a given level of precision with the least effort, probably vary with vegetation type and with goals of the study. Hanley (1978) compared line interception and visual estimation within quadrats in big sagebrush communities. He concluded that line interception gave higher precision but that quadrat estimation could be a faster method for less precise cover estimates. Floyd and Anderson (1987) compared line interception, cover-class estimation, and point interception in sagebrush steppe vegetation. They concluded that line and point interception were more precise than cover-class estimation for sampling species other than the dominant shrubs and that point interception was the more efficient of those 2 sampling methods because it required less effort to achieve the same degree of precision.

The goal of this study was to identify sample sizes required to characterize, with various levels of precision, vegetation in a sage-steppe community using a point-interception technique. I performed Monte Carlo simulations using data from 4 transects in each of 4 plots to calculate the range in cover estimates and 95% confidence intervals for varying numbers of point frames. I also compared 2 types of point frame samples, one that used 50 sample points per frame and another that used 36. Results presented here can help in designing an efficient sampling protocol that will result in a desired level of confidence.

STUDY SITE

This study was conducted at the Idaho State University (ISU) ecological research area located southeast of the ISU campus on Barton Road, Pocatello, Bannock County, Idaho. This roughly 26-ha area is situated at 1450 m elevation on the east side of the Portneuf River valley, 25 km south of the Snake River plain. The climate is semiarid, with cold winters, moist springs, and warm, dry summers. Annual precipitation at the Pocatello Airport (17 km from the site, 1359 m elevation) averages 30.8 cm, with July–October having the lowest average monthly total precipitation. Because of the local topography, average precipitation at the study site is probably slightly greater than at

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the Pocatello Airport. Soils at the site are deep, well-drained, calcareous silt loams that are neutral to moderately alkaline near the surface and moderately to strongly alkaline at depths of 20–150 cm (McGrath 1987).

The study area, acquired by ISU in 1995 and designated as an ecological research area in 1996, has not been cultivated but may have been subjected to low levels of grazing by domestic livestock during the latter part of the 20th century, prior to 1990. From about 1990 to 1996, anthropogenic disturbance was limited to occasional horseback riding and hiking, primarily along established paths.

METHODS

Four 20 × 20-m plots were established in April 1996 in a 1.4-ha area that was fenced to minimize disturbance from humans and domestic livestock. Plots were separated by at least 5 m; the greatest distance between 2 plots was about 60 m. Plot locations were chosen to have similar cover of the dominant shrubs and to avoid drainage channels that were 20–60 cm lower than adjacent areas.

Four 12-m-long transects were established within each plot. The ends of each transect, marked with metal stakes approximately 30 cm high, were located 4 m from the east and west sides of each plot. Transects were spaced 4 m apart with 4 m between the outside transects and the north and south sides of each plot.

During the period 13–19 July 1999, I sampled the vegetation, estimating percent cover using a point frame, modified from Floyd and Anderson (1987). The point frame held 2 layers of strings, one 14 cm above the other. Each layer consisted of a 5 × 10 grid of strings spaced 10 cm apart, with 5–6 cm between the outside strings and the inside of the wooden frame. The point frame was placed and leveled at 1-m intervals along each transect, with the long axis of the frame perpendicular to the transect. For the first sample along each transect, a corner of the frame was placed at the beginning of the transect (0 m), and for the last sample along each transect the same corner was placed at the end of the transect (12 m), for a total of 13 frames per transect and 52 frames per plot. At each location I recorded cover of the 50 points that fell below vertical pairs of grid intersections. Shrubs and forbs were recorded only if a leaf or stem fell under a point. Perennial bunchgrasses were recorded only if the base of the bunchgrass fell under a point. If 2 vascular plant species were present under a point, I recorded both species.

For the purposes of this study, I treated each point frame as a separate sampling unit. To characterize the relationship between cover estimate and sample size (# frames), the frames were drawn in random order, without replacement, and total and average cover were calculated after the addition of each frame until all 208 frames were drawn. This process was repeated 1000 times, and 95% confidence intervals (CIs) were estimated by identifying the high and low cover estimates that included 950 of 1000 values for each sample size. This analysis was performed separately for individual vascular plant species, shrubs, perennial grasses, and forbs.

This process was repeated to compare the effectiveness of sampling 50 points per frame with Floyd and Anderson's (1987) point-frame design that used 36 points for each frame. For this analysis a 4 × 9 grid of points was selected from the same relative position in each frame and the randomization procedure was performed in the same manner as the full 50-point samples.

Various criteria can be used to assess whether a sample is sufficient to adequately characterize vegetative cover. The approach I have used is to consider the width of the 95% confidence interval relative to the mean. The required level of precision may vary depending on the specific goals of a given study. Here I present results in terms of sample sizes required to achieve a 95% confidence interval that is equal to either the mean or one-half of the mean.

RESULTS

Shrub cover ranged from 25.1% to 35.0% on individual plots (mean of 52 frames on each plot) and averaged 30.6% over the 4 plots (mean of 4 plot means). Perennial grass cover averaged 22.0% (19.7–26.7% on individual plots), and forb cover averaged 2.1% (1.1–3.7% on individual plots). The dominant shrub species on all plots was *Artemisia tridentata* spp. *tridentata,* which was responsible for more than 95% of the shrub cover. Cover of *A. tridentata* averaged 29.3% on the 4 plots; individual plot averages ranged from 24.5% to 33.8%.

The most abundant perennial grasses were *Elymus lanceolatus* spp. *lanceolatus* (thick-spiked wheatgrass; 16.5% cover), *Stipa comata* (needle-and-thread grass; 3.8% cover), and several species of *Poa*, which are combined here because of uncertainties in identification. *Sitanion hystrix* (bottlebrush squirreltail) was recorded on 2 plots, with cover values of 0.04% and 0.12%. Twelve forb species were recorded on the plots, none of which contributed more than 2% cover on any plot, and none of which averaged more than 0.6% cover. The 2 forb species that had the highest average cover were *Plantago patagonia* (desert plantain; 0.6% cover) and *Phlox hoodii* (0.3% cover). The most abundant annual plant was *Bromus tectorum* (cheatgrass), which contributed an average of 34.3% cover (19.0–50.4% on individual plots).

Sets of 1000 random draws were sufficiently large to give fairly smooth relationships between estimated cover and sample size (Fig. 1). The 4 lines in each figure converge at a sample size of 208 because this was the total sample of frames, and random draws were done without replacement. The range of cover estimates and the width of the 95% CIs decreased rapidly as sample size increased from very small numbers and then decreased more slowly until the number of frames approached 200 (Figs. 1, 2). The number of frames required for the 95% CI to be equal to average cover varied considerably among species and was much larger for species with lower average cover. For more abundant species or groups (e.g., shrubs, perennial grasses, *Artemisia tridentata, Elymus lanceolatus, Bromus tectorum*), sample sizes of fewer than 50 frames were adequate to achieve a 95% CI equal to one-half of the species' average cover. For rarer species or groups (e.g., forbs), the same sample size was not sufficient to reduce the width of the 95% CI to the average cover of the group or species.

Figure 3 shows relationships between sample sizes required to achieve a 95% CI equal to either mean cover or one-half of the mean. In both cases the relationship can be fitted with a power function ($Y = aX^{-b}$) that is statistically significant.

When the number of points per frame was reduced from 50 to 36, the number of frames required to achieve a given width of CI was in nearly all cases increased. The absolute increase in number of frames was small for more abundant species or groups (e.g., from 43 to 45 for shrubs, from 20 to 24 for perennial grasses), but was larger for less abundant species (e.g., 147 to 155 for forbs).

DISCUSSION

Floyd and Anderson (1987) compared 3 methods for estimating plant cover in a shrub steppe community and reported that point interception was more efficient than line interception or cover-class estimation for obtaining cover estimates for most species in the plant community. In this study I examined the effectiveness of point estimation more closely, asking

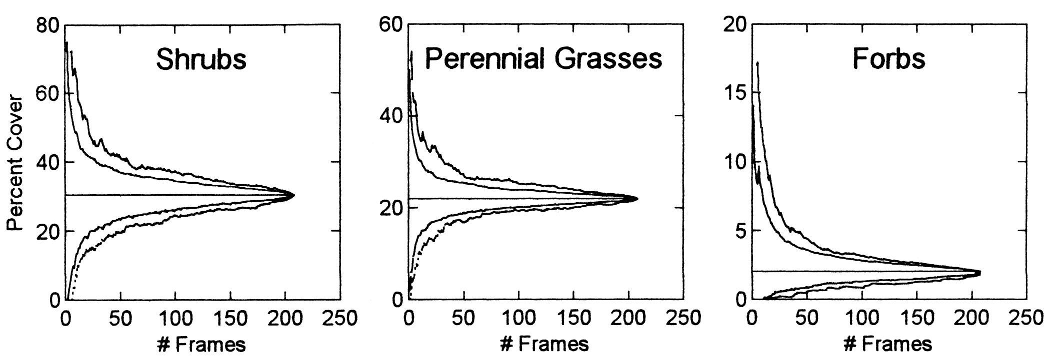

Fig. 1. Relationships between estimated cover and sample size for 3 species groups. For each graph, the horizontal line shows average cover for all 208 frames, and the outside curved lines represent minimum and maximum cover estimates for each sample size. The area between the 2 inner curved lines contains 95% of the cover estimates. The *y*-axis, which is scaled differently for each graph, was truncated so that maximum values for very small numbers of frames are not shown.

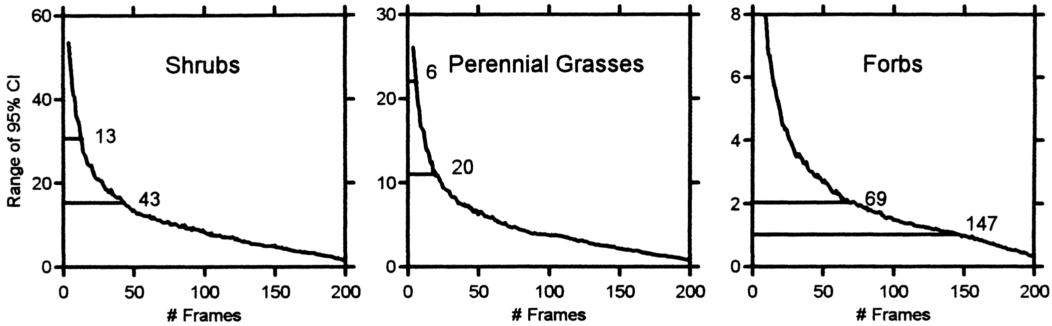

Fig. 2. Relationships between the width of the 95% confidence interval and the number of sample frames for 3 species groups. The upper horizontal line shows average cover; the number at the intersection of that line and the curved line is the number of frames required to achieve a 95% CI equal to that value. The number associated with the lower horizontal line is the number of frames required to achieve a 95% CI equal to one-half of average cover.

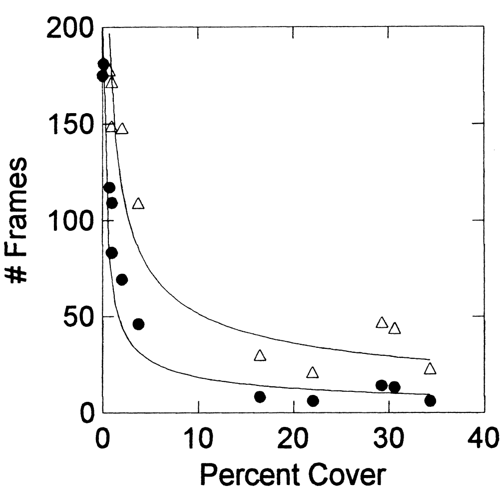

Fig. 3. Number of sample frames required to achieve a 95% CI equal to average percent cover (open triangles) or equal to one-half of average percent cover (closed circles). Each point in this figure represents 1 species or 1 group of species (e.g., shrubs). Curves drawn through each set of points are power functions of the form $Y = aX^{-b}$; both relationships are statistically significant ($P < 0.01$).

how large a sample size was needed to achieve a particular confidence interval and how the required sample size was influenced by the number of points per sample frame.

The wide range of cover estimates obtained with sample sizes less than 40 reflects the spatial heterogeneity that is typical of shrub steppe communities. At a gross scale these communities consist of shrubs and intershrub spaces, and cover estimates vary widely until the number of samples is large enough to include this spatial variation. This was true even for the most abundant species and species groups. At sample sizes of 50–150, the range of cover estimates decreased much more slowly, indicating a smaller increase in precision with increased sampling effort. The precise nature of the relationship between sample size and precision at the largest sample sizes is suspect because samples were randomly drawn without replacement, and thus the largest sample sizes mostly comprised the same set of samples.

As average cover declined below 4%, the number of sample frames required to achieve a 95% CI equal to the average increased dramatically (Fig. 3). Setting a goal of reducing the 95% CI to the average is likely to be unrealistic for these species. Instead, reducing the width of the 95% CI to an arbitrary value (e.g., 2%) may be more realistic. Even for rare species this usually could be achieved with sample sizes less than 100 (74 for forbs).

Reducing the number of points per sample frame from 50 to 36, the number used by Floyd and Anderson, increased the required number of frames to achieve a given 95% CI. The increase in frames, however, was less than the 28% decrease in points per frame. This is because the size of the sample frame (0.5 × 1 m) is small relative to the spatial variation in vegetation; adding points within a frame will provide a better estimate of local cover but will be less effective at sampling the community as a whole. In terms of sampling efficiency, however, there is still likely to be an advantage in sampling more points per frame. Much of the time associated with this sampling technique is devoted to establishing transects and locating and leveling the sample frame. Sampling 14 additional points per frame requires a relatively small increase in sampling effort.

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