Optimum Size of Sample for Hand Separation of Forage Crop Mixtures into Their Component Species in Small Plot Experiments

R. G. Petersen and D. S. Chamblee

In small plot experiments with forage crop mixtures, it is often desirable to obtain an accurate estimate of the effect of treatment or environment on the botanical composition of the mixture. Although several more rapid procedures have been proposed (4, 11) the most accurate estimate of botanical composition is obtained by hand separating a sample of the forage from the plot into its component species (1, 10). In addition, a sample must be hand separated if chemical analyses are to be run on the individual species in the mixture. Since hand separation is an expensive procedure, the sample to be analyzed should be selected in a way that provides the maximum accuracy at a minimum cost.

Much of the previous work on size of sampling unit in forage investigations has been concerned with estimating the botanical composition of native ranges. Pechanec and his co-workers (6, 7) have rather extensively investigated sampling procedures for the botanical evaluation of range mixtures. Their results, however, are not directly applicable to small plot work. Sprague and Myers (10), working with small plot experiments, concluded that a sample 2 inches wide and as long as the plot should be clipped from a random location in the plot. One-fourth of the sample should then be hand separated to estimate the botanical composition of the plot. They found that the accuracy of estimation was increased more by restricting the number of samples per plot to one and increasing the number of plots per treatment than by increasing the sampling rate within the plot. However, costs were not considered in arriving at these conclusions.

The yield of forage mixtures in many small plot experiments is estimated from a strip clipped with a mower from the center of the plot. This paper is concerned with determining the size of subsample to be selected from this yield-strip sample to obtain an estimate of the botanical composition of the plot. No attempt was made in this study to investigate plot size and shape, since this subject has received considerable attention from other workers (3, 8, 9).

MATERIALS AND METHODS

Two forage crop experiments were used in this investigation; in one several rates of nitrogen were studied, and in the other various management practices. Both were uniformly seeded with a mixture of white clover, low hop clover, bromegrass and orchard grass during the fall prior to this study. In the nitrogen experiment, certain of the plots had received nitrogen fertilizer, at rates of 0, 50, or 100 pounds of elemental nitrogen per acre, on March 15, 1945, 6 weeks before the plots were harvested.

In the management experiment, no supplemental fertilizer was applied but certain plots had been harvested in the clipping used for this study.

The individual plots in both experiments were 25 feet wide and a yield-strip sample 2 feet wide was cut from the center of each plot with a mower. The fresh herbage from this strip was immediately bagged and brought into the laboratory where fresh weight was recorded and random subsamples taken for hand separation. Each subsample was weighed to insure that about one fourth of the same quantity of fresh herbage.

In the nitrogen experiment, consisting of 42 plot samples, each containing 20% of the total herbage, random subsamples were taken from seven of the yield-strip samples, each containing 10% of the total herbage, from the remaining 35 plot samples. In the management experiment, consisting of 21 plots, four 10% subsamples were taken from each yield-strip sample. Each subsample was hand separated into its component species and green weights were oven dried. The average weight of the yield-strip sample for the nitrogen and management experiments were 331 grams of oven-dry forage. The weight of the subsample was then expressed as a percent of the total dry weight of the subsample.

Statistical Theory and Methodology

Theory.—The underlying principle involved in determining the optimum size of subsample is that of minimizing a given variance, or, alternatively, minimizing a given cost. With the subsampling procedure under consideration, the variance, $V_s$, of a species mean (on a per subsample basis) is given by

$$V_s = \frac{\sigma^2_r}{r} + \frac{\sigma^2_s}{rs}$$

where

- $\sigma^2_r$ is the species variation between plots (yield-strips alike);
- $\sigma^2_s$ is the species variation from subsample to subsample in a plot (yield-strip sample);
- $r$ is the number of plots per treatment;
- $s$ is the number of unit subsamples per plot.

The total cost, $C_s$, of obtaining an estimate of the botanical composition of the plots from a particular treatment and sampling procedure may be expressed as

$$C_s = rC_r + rsC_s$$

where

- $C_r$ is the cost per plot if no subsamples are hand separated;
- $C_s$ is the cost of selecting and hand separating a subsample;
- $C_{ss}$ is the cost of hand separating a subsample and running chemical analyses.

When the variance is of the form given by (1), $V_s$, the cost described by [2] it can be shown (5) that the optimum variance will be a minimum if the number of unit subsamples per plot, $s_{opt}$, is given by

$$s_{opt} = \sqrt{\frac{C_r \sigma^2_r}{C_s \sigma^2_s}}$$