A statistical comparison of the line interception, vertical point quadrat, and 3-step methods as used in measuring basal area of grassland vegetation in southern Alberta
by Alexander Johnston

A Thesis Submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of Master of Science in Range Management
Montana State University

Abstract:
The study was designed to arrive at the most efficient sample size and number when using the line interception, point quadrat, and 3-Step methods of vegetative analysis in four range types in southern Alberta. These range types were representative of the Festuca-Danthonia association of the fescue grassland, and of the Aqropyron-Stipa associes and Bouteloua-Stipa faciation of the mixed prairie.

At each site a total of 10 transects each 100 feet long were laid out, spaced 10 feet apart, and parallel to each other. Basal area measurements of all species encountered by each method at each site were obtained and the data were so arranged that each 10 foot segment of each 100 foot transect could be later identified. This, in effect, gave a total of 100 plots at each site, in each of which basal area measurements had been obtained by three methods, which were available for study and analysis.

Sampling intensities sufficient to sample the dominant and secondary species to within ± 10 percent of their true mean basal areas are shown.

The precision obtained when the secondary species are sampled at intensities found adequate for the dominant species are also indicated. Measurement of secondary species at these intensities was highly variable for the most part.

Regression lines were plotted and correlation coefficients calculated for various combinations of methods and show, in general, that a high degree of relationship exists between the methods.

The variability of some native species encountered is discussed and types of curves obtained when their frequency distributions are plotted are shown.

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ABSTRACT

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INTRODUCTION

The objective of the study being reported was to attempt, by statistical methods, to arrive at the most efficient sample size and number to be used in conjunction with the line interception, point quadrat, and 3-Step methods of vegetative analyses. The areas studied have never been investigated with evaluation of sampling procedures as an objective. Herein lies an important phase of the study, for, as Goodall (1952) points out:

> "An answer cannot be given *a priori* to the question of how many points are required to give a specified degree of precision, but must be derived from observations directly on the vegetation concerned."

His remark applies equally well to intensity of sampling by any other method of study.

Many papers have been written which pertain to ecological sampling. Most deal with the proper size, shape and number of plots which constitute the most efficient sample, or which yield the greatest amount of precision for the least amount of time or money spent. The problem has been attacked empirically by use of the species area curve (Cain, 1938), or by statistical methods (Clapham, 1932)(Ashby, 1935) (Pehance and Stewart, 1940) (Penfound, 1945).

REVIEW OF LITERATURE

The point quadrat method was first used by workers in New Zealand (Levy and Madden, 1933). As modified for use in western Canada (Clarke et al, 1942), the method involves the use of a wooden frame one yard long with thirty-six metal pins inserted vertically at one inch intervals. The frame is dropped at predetermined intervals of from ten to thirty paces in transects across the area to be sampled. In recording vegetation, a plant is hit when the point of a pin touches its base. Hits for each species are recorded and are expressed in terms of percentages of total number of points studied. The influence of shrubs in a vegetative complex is thought to be greater than their basal areas would indicate hence contacts of the pins of the sampling apparatus with the branches and foliage of these species are recorded and not those made at the surface of the ground (Coupland, 1950).

The sampling intensity required in using the point method is thought to be a function of the grass cover (Clarke et al, 1942) and varies from 3600 points where total basal area is about 5 percent to 2400 points where it is about 18 percent.

In the United States Hanson (1934) was apparently the first to use the method. He compared the point method with various types of quadrats and concluded that valuable information could be obtained by its use since large areas could be quickly sampled. Hanson used the point method in determining the characteristics of major grassland types in North Dakota and used 300 points per stand of 2 to 20 acres to sample these areas.

Ellison (1942) compared the point method with the area-list and pantograph chart methods. He found basal areas obtained by the point method were very close to those obtained by the area-list method. In addition, results by the point method were more consistent and were more efficient in vegetation of high density. The point method had the additional advantage that its efficiency could be increased by increasing the number of points examined.

In Australia, after a comparison of methods, the point method was chosen for regional grassland surveys (Crocker and Tiver, 1948). Its most valuable features were:

"(a) it permits quantative determination of botanical composition in terms of cover, which is probably the most suitable ecological expression of recording change; (b) it is objective and more rapid than other methods of equal reliability and objectivity; (c) it provides for randomization and ample replication of sampling; (d) it also permits close examination of all, or nearly all, species present, and gives plenty of scope for observation; (e) it does not depend entirely on random distribution of species for its usefulness, and (f) it does not in any way interfer with the vegetation."

These investigators felt that 300-500 points per 14-150 acre field were sufficient for adequate sampling and stated that uniformity of treatment was more significant than area in determining the number of points required.

Goodall (1952) has published a critical analysis of the point method. He points out that pin diameter may have a marked effect on data obtained. Equal distribution of points over the area to be studied was suggested, rather than random distribution of individual points or groups of points. Where plant succession is being studied, successive observations should be made at the same point. Slight differences between observers recording the same vegetation were noted but Goodall concludes:

> "It remains one of the most trustworthy methods available to the ecologist, and one of the most nearly objective."

Modifications of the point method have been variously called the point transect method (Coupland, 1952): the point contact method (Hanson, 1950), the frequency point method (Parker, 1950), and the inclined point quadrat method (Tinney et al, 1937). These, and other, modifications are in wide use (Goodall, 1952).

The line interception method (Canfield, 1941) is a modification of the line transect and is:

> "A procedure for sampling vegetation based on the measurement of the intercept of all plants occurring on the courses of lines of equal length."

Length of lines used varies with the density of vegetation, lines 50 feet in length being recommended when the ground cover is 5 to 15 percent, and 100 feet when the ground cover is less than 5 percent. Not less than 16 sampling lines should be randomly located in the area to be sampled regardless of size of the area.

A modification of the method, involving a belt one centimeter wide and 10 meters long, was used by Savage (1940) in measuring vegetation of the southern Great Plains and was thought to be suitable in light of the conditions encountered. Vegetation in the study area consisted of a mixture of brush and low-growing grasses.

Hanson (1950) in his discussion of the line interception method concludes that it is most suitable for use in vegetation where shrubs are growing in mixture with grasses and forbs and not so well suited to dense grassland types.

Modifications of the line interception method have been used to measure utilization (Canfield, 1944) and yield (Hormay, 1949).

A method, designated as the 3-Step method, has been developed for use in appraising condition and trend on national forest range in the western United States (Parker, 1950) (Parker, 1951). Trend refers to the influence of:

> "A complex set of factors relating to the vegetation, soil, and native animals both large and small, and even micro-fauna, which are constantly changing from one growing season to the next. Both range administrators and stockmen are interested in whether these changes are in the direction of improvement or in a downward trend of deterioration. They want to know how much of the change is due to current weather and how much to grazing use."

Condition has been defined as the state of health or productivity of both soil and forage of a given range, in terms of what it could or should be under normal climate and best practical management. Dyksterhuis (1949) has defined condition as "The percent of present vegetation which is original vegetation for the site." The essential difference between condition and trend hinges on the time factor. Condition refers to the state of a range at a particular time; trend, to changes which take place over a period of time.

The 3-Step method represents a combination of the more desirable features of several methods (Parker, 1950). In practice, a line transect is laid out and the vegetation, or other materials, appearing in a 3/4 inch loop dropped at predetermined intervals along the line, is recorded. The 3/4 inch loop represents a compromise between a point, discarded because of the difficulty of replacing it at the same spot on successive occasions, and a small plot, discarded because of the additional variation which its use introduced.

Recommended procedure, when using the 3-Step method is to group the line transects in clusters of from one to three depending on the density of vegetation, and to use a minimum of two clusters to afford a larger sample of the vegetation, and to help ensure that no rare species are overlooked. The practice of grouping transects in clusters also provides a measure of the variation within a sampling site and helps smooth out the differences between men.

At present a good deal of interest is being shown in the method, literature to date dealing primarily with improvements in technique (Short, 1953) or with tests of its adaptability (Sharp, 1954).

The work of Costello and Kipple (1939) represented a major contribution to an understanding of the sampling of range vegetation. Using the standard error as a measure of sampling intensity, they showed that the law of diminishing returns applies to accuracy of surveys by the method studied. Further, they found that different vegetative types require different sampling intensities for a given degree of accuracy; that little relationship exists between the area of a vegetative type and the number of plots required to sample it to a given degree of accuracy; and that different portions of a type generally require different numbers of plots for a given accuracy. Seasonal and yearly fluctuations in floristic composition resulted in similar fluctuations in the sampling intensity necessary to survey the same area to a given accuracy.

Poulton (1948) discusses sampling techniques in range forage inventory and points out that every population has its own optimum sampling design. This emphasizes the need for a definition of the individual population, to be followed by the determination of a proper sampling design. A few investigators (Hanson, 1934) (Pehanec and Steward, 1940) have utilized this approach.

Well over 100 uniformity trials have been reported in the literature (Koch and Rigney, 1952), most dealing with the determination of optimum plot size, shape, and number in agronomic research. A few have dealt specifically with native range vegetation (Hanson, 1934) (Costello and Kipple, 1939) (Pehanec and Stewart, 1940).

Pehanec and Stewart (1940) studied sampling intensity of native sagebrush-grass range in Utah. They concluded that the smaller the sampling unit the more efficient it is per unit of area. However, they point out that an effective balance must be attained between statistical efficiency and such practical factors as the amount of work involved and the accuracy of observation.

Using the same data (Pehanec and Stewart, 1941) variability of native vegetation was studied. In general, frequency distributions were found to be strongly skewed to the right, a characteristic of native vegetation which has been noted by many investigators (Robinson, 1954). Sampling intensities were found to vary greatly with the species studied. A sampling intensity sufficient to give a sampling error of 5 percent of the mean of major species and 10 percent for secondary species was thought to be an effective compromise. This can be more effectively attained by sampling several replicates of the same treatment rather than increasing the sampling intensity of a single replicate.

In most studies of ecological sampling, statistical variance, or some statistic derived from the variance, has been used to determine the most favorable size, shape, and number of plots. Suitable procedures whereby variance can be used for this purpose are outlined in various publications (Schumacher and Chapman, 1948) (Snedecor, 1950). Bormann (1953) has utilized statistical variance in a study of sample plot size and shape in forest ecology.

DESCRIPTION OF THE AREA

1. General Description:

The grassland area of Alberta extends from the foothills of the Rocky Mountains eastward to the Alberta-Saskatchewan boundary. It is bounded on the north by the aspen parkland and extends some 300 miles northward from the International border along the Alberta-Saskatchewan boundary. Within this area two grassland associations are recognized. The mixed prairie region (Coupland, 1950) forms a rough triangle from the base of the foothills of the Rocky Mountains, along the International border, and northward along the Alberta-Saskatchewan boundary for about 250 miles. The sub-montane prairie or fescue grassland lies to the north and west of the mixed prairie (Clements, et al, 1939; Clarke, et al, 1942; Moss, 1944; and Moss and Campbell, 1947) and is associated, to some extent, with the aspen parkland.

This grassland area forms part of the Great Plains physiographic region. It is made up of the Plains region -- further sub-divided into the Shortgrass zone, the Cypress hills, and the Northern prairie -- and the foothills region (Vrooman, et al, 1946).

The plains region is characterized by gently rolling topography, with an average elevation of about 3000 feet, cut occasionally by deep coulees or river valleys from 100 to 500 feet in depth. The continuity of this plain is broken by the Cypress hills which rise abruptly to elevations of 4200 feet. The foothills region, with an average elevation of about 4000 feet, consists of rolling hills which fringe the eastern slope of the Rocky Mountains from the International border northwards. Many of the hills are broadly rounded, with grassy benchlands, and are separated by wide valleys.

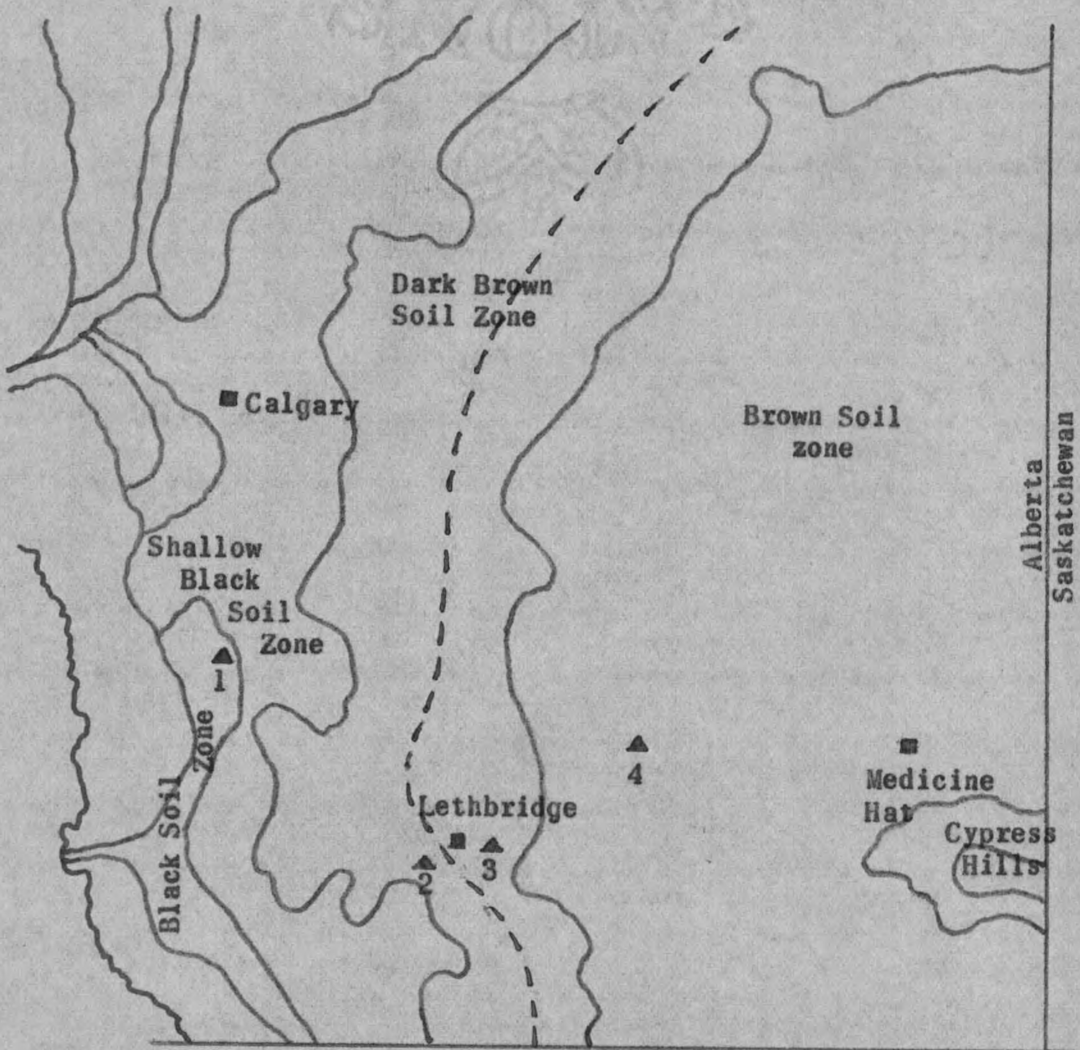

Figure 1. Vegetative and soil zones of southern Alberta. The broken line shows the approximate boundary between the mixed prairie to the south and the fescue grassland to the north and west. Study sites are indicated as follows: 1. Stavely Grassland Sub-Station. 2. Veterinary Research Station. 3. Dominion Experimental Station at Lethbridge and, 4. Dominion Experimental Sub-Station at Vauxhall.

Soils of the region range from the brown and chestnut soils of the dry plains to the black Chernozem soils of the foothill valleys. Most of the area has been glaciated hence the parent material for most soils is of mixed origin. With the exception of the foothills, drainage of the area is not yet fully established and many small sloughs, often containing a high concentration of soluble salts, are common. Soils in these depressions are frequently heavy in character and contain a high proportion of clay. In the foothills, the valleys usually have deep black soils while the soils of the ridges are lighter loams with frequent gravel and rock outcrops.

Climatic conditions vary but are generally dry and continental in character. Precipitation varies from 11.71 inches per year at Manyberries to 20 inches or more along the foothills and in the northern portions of the area. Extremes of temperature are encountered although severe winter temperatures are frequently amelioriated by warm winds from the west. These warm winds are known locally as the Chinook. During the summer months these same winds cause rapid drying of the soil and vegetation. Climatic data of interest is shown in Table 1.

Table 1.
Climatic Data from Representative Stations in Southern Alberta [1]

Station	Mean Annual Temp. in °F.	Average ppt.		Evaporation in inches
		Annual	April-July	
Pincher Creek	39.0	19.93	9.74	--
Lethbridge	41.2	15.76	7.82	24.6
Medicine Hat	42.0	12.70	6.70	--
Manyberries	40.5	11.71	6.30	33.17

[1] Clarke and Tisdale, 1945.

EXPERIMENTAL PROCEDURE

1. Procedure in the field:

At each study site a uniform area was selected by visual inspection. A total of ten 100 foot transects were then laid out, placed 10 feet apart, and parallel to each other. These transects were marked by three stakes placed at the 0.5, 50.5, and 99.5 foot marks. A 100 foot metal tape, graduated in 1/100ths of a foot, was tightly stretched along the transect as close to the ground surface as possible, and anchored at each end by a steel pin. Measurements, by each method, were made along the edge of this tape.

When measuring by the line interception method, the intercept of plant crowns, on a vertical plane directly below the edge of the tape, was measured to the nearest 1/100th foot and recorded by species. Measurements by the point method were made by placing a frame containing thirty-six points directly over the tape in such a way that the pins touched the tape along its length. Points were therefore examined at one inch intervals along the 100 foot length of the transect. Any point hitting the crown of a herbaceous plant was recorded by species. With shrubs, those points hitting the above ground portion of the plant were recorded since the influence of these plants is felt to be greater than their basal areas, obtained by only recording basal hits, would indicate.

When using the 3-Step method, a 3/4 inch loop was dropped at intervals of one foot along the length of the tape in such a way that a vertical plane below the edge of the tape would bisect the loop. Crown portions of vegetation, or other materials such as rocks and litter, which appeared in