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BOTANICAL COMPOSITION OF PRAIRIE VEGETATION IN RELATION TO CERTAIN SITE CHARACTERISTICS AND MANAGEMENT PRACTICES

by

Fahrettin Tosun

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TITLE

Botanical Composition of Prairie Vegetation in Relation to

Certain Site Characteristics and Management Practices

BY

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BOTANICAL COMPOSITION OF PRAIRIE VEGETATION IN RELATION TO CERTAIN SITE CHARACTERISTICS AND MANAGEMENT PRACTICES

Fahrettin Tosun

INTRODUCTION

Much of the True Prairie Region is now under cultivation, but large acreages in Nebraska, Kansas, and neighboring states remain unbroken and are an important resource in livestock production. Many prairies, undisturbed except for annual mowing for hay, still support climax, or near climax, vegetation. Studies of the influence of grazing upon prairie vegetation indicate the necessity of proper management to improve already deteriorated pastures and to maintain the productivity of rangelands that are in better condition. Knowledge of the behavior of the vegetation under different practices is essential to the proper management of grasslands. The ecology of the true prairie has been studied rather extensively but the relationships between the vegetation changes noted and specific management practices have not been clearly established.

This study was initiated to determine the botanical composition of native prairie vegetation in relation to topography, soil texture and water-holding capacity, precipitation, and certain management practices. The research was conducted at two locations, the Dalbey section in eastern Gage County and near Beaver City, in Furnas County, Nebraska. Average annual precipitation at the two locations is approximately 30 and 20 inches, respectively. Preliminary to the surveys, the line-interception and point-contact methods of vegetation analysis were compared and sampling procedures were developed and evaluated.

LITERATURE REVIEW

Structure of True Prairie Vegetation

The true prairie of the central grasslands of North America is among the most thoroughly investigated of all vegetational regions. Weaver and his students (Weaver 1950, 1954a, 1954b; Weaver and Albertson, 1956; Weaver and Fitzpatrick, 1934; Steiger, 1930; Tolstead, 1942; and others) have treated in detail the compositional variation within the grasslands ascribed to habitat factors. They have recognized, in general, lowland and upland communities in the true prairie area. The water content of soil was considered the most important factor determining the differences in the structure of the vegetation. Prairie of the more moist lowlands is dominated by grasses that are different from those typically forming upland communities. The characteristic community of lowland is dominated by *Andropogon gerardi*[1/] and that of upland is dominated by *Andropogon scoparius*. The most abundant grasses of lowlands are *A. gerardi*, *Sorghastrum nutans*, *Poa pratensis*, *Spartina pectinata*, *Panicum virgatum*, and *Elymus canadensis*. The upland communities consist principally of *A. scoparius*, *Bouteloua curtipendula*, *Koeleria cristata*, *Stipa spartea*, and *Sporobolus heterolepis*.

Weaver and Hansen (1941) and Weaver and Albertson (1944) studied the changes and the recovery of the true prairie vegetation due to the great drought of 1933 to 1940. In general, major species of true

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1/ Scientific and common names and standard symbols for all plant species mentioned in this paper are listed in the appendix.

prairie were replaced in part by the grasses, Agropyron smithii, Buchloe dactyloides, Bouteloua gracilis, Festuca octoflora, Bromus secalinus, B. tectorum, Hordeum pusillum, and weedy forbs such as Aster multiflorus, Erigeron ramosus, and others.

The resistance of the native species of true prairie to the drought varied with the species. Some species disappeared entirely while others remained only in small amounts. Andropogon scoparius suffered the most and the stands of this species were depleted severely. A. gerardi, Poa pratensis, and Sporobolus heterolepis were greatly reduced in numbers but small amounts remained in most of the meadows. With the return of abundant moisture A. gerardi and Poa pratensis increased rapidly by vegetative spread and by seed; and they became the dominant species on large areas of upland. The recovery of S. heterolepis was suppressed by A. gerardi.

The studies on the effects of grazing upon true prairie vegetation were recently reviewed by Ellison (1960). Weaver and Hansen (1941) classified the prairie grasses and forbs as decreasers, increasers, and invaders under the influence of grazing. In general, they found that tall grasses were replaced by mid- and short grasses and these subsequently were replaced by invading weeds under the influence of continued heavy grazing.

Vegetation Survey Methods

The need for using quantitative measures in vegetation studies has made it necessary to give serious consideration to methods of sampling.

Many of the vegetation survey methods which have been developed for botanical analyses have been reviewed and compared by Hanson (1938, 1950), Ahlgren (1947), Brown (1957), and Phillips (1959).

Considerable work has been done on the influence of size, shape, number and location of sampling units. Hanson (1938) used the term "sample area" for a small portion of a larger plot in preference to "quadrat" because the latter means a square area while a "sample area" may be oblong or circular. He concluded that the plot system with included sample areas yielded data of greater reliability than individual sample areas distributed in the entire area without grouping. In the plot system, study plots are located in the area at random and a number of sub-samples (sample areas) are examined in each plot. A sufficient number of sample areas should be studied in each plot to obtain reliable data. The number of sample areas needed in each plot to secure a specified degree of accuracy is dependent upon the size and shape of the sample area and the nature and distribution of the species composing the vegetation (Hanson, 1938; Ashby, 1948; Goodall, 1952b; and others). On the native prairie of North Dakota, Hanson (1938) found that the minimum desirable size of plots was 2 x 3 rods. Twenty-four sample areas, each 0.1 square meter in size, were examined in each plot. Seven plots were needed to obtain reliable data in each community under study. The number of sample areas needed per plot has been determined by means of subjective procedures such as: (1) the species-area curve (Hanson, 1938; Oosting, 1958), (2) the oscillation curve of successive

sample means (Greig-Smith, 1957); and (3) by statistical methods (Johnston, 1957; Whitman and Siggeirsson, 1954).

It has been concluded that a long narrow sample area is more efficient in reducing the standard error than a square or nearly square sample unit of the same area. This is due to the long plot cutting across more aggregations or societies of species than a square one (Ashby, 1948; Brown, 1957).

Natural vegetation is highly variable. Consequently, observation of a large number of samples is necessary to obtain a satisfactory degree of accuracy. For this reason, many investigators have attempted to estimate rather than measure the characteristics of the vegetation. Estimation methods have an important place when large areas must be surveyed, but generally, they do not give the accuracy needed in detailed research. Therefore, when the vegetation of a small area is studied for detail, actual measurement of characteristics is desired.

Many methods have been developed for determining various characteristics of vegetation. In most of these methods, the importance of a plant species is determined on the basis of one or more of the following: (1) frequency of occurrence, (2) number of individuals, (3) area covered, and (4) weight. Clarification of these concepts regarding inherent characteristics of plant communities has been given by Hanson (1938 and 1950) and Brown (1957).

<u>Frequency</u>.--The importance of a species can be measured by determining its presence or absence in the sampling units. The number of

sampling units in which the species occurs in relation to the total number of units examined is the <u>frequency</u> of that species. Usually this is expressed in percentage.

Frequency indicates the degree of dispersion or uniformity of distribution of the individuals of a species within an area. The first method used for frequency determination was the stick and radius rod method of Raunkiaer (Brown, 1957; Phillips, 1959). Several modifications of this method have been developed. In Raunkiaer's method, the sampling unit is a circle 0.1 square meter in area. Stapledon, in Great Britain, used a 6" x 6" grid and de Vries a sampling area of 25 sq. cm. (Brown, 1957).

Summerhays (1941) used a modification of Raunkiaer's method for recording changes in vegetation by means of frequency charts. In the frequency-charting method, the sampling units are distributed at various intervals along a straight line. Each sampling unit is divided into ten equal sub-units, then the frequencies (0 to 10) for each species are graphed to a scale. In this method, sampling is not at random, consequently, it is impossible to obtain a valid estimate of the random sampling error (Brown, 1957).

As stated by Penfound (1945), "frequency is apparently the most artificial and least important characteristic of the vegetation". However, some investigators have combined frequency with abundance, cover, or rank. McGinnies (1934), Ashby (1935), Blackman (1935), Clapham (1936), and Singh & Das (1939) found a logarithmic relationship

between density and absence (100 minus percentage frequency). Therefore, if frequency readings are converted to density through the logarithm of the percentage absence, they can give the information required for critical and intensive studies of vegetational changes, where the species are distributed at random in the community.

It has been shown that frequency varies with the size and shape of the sampling unit and with the distribution of the species (Curtis and McIntosh, 1950; Brown, 1957; Aberdeen, 1958). Small sampling units give relatively lower frequency ratings than larger units and the less abundant species may be missed entirely.

Frequency data have been used as indices of per cent basal area or plant cover. In the "three-step method" of Parker (1951) the per cent of plots containing perennial vegetation is designated as "loop-density index". Johnston (1957), Sharp (1954), Short (1953), and Hutchings and Holmgren (1959) have evaluated various features of the loop-index method for detecting changes in plant cover.

Hanson (1950) stated "the frequency-index has proven to be a valuable method for comparing different types of vegetation, different treatments of the vegetation, changes in the same community, the effects of micro-topography, and in evaluating the importance of species in different communities and at different times within the same community". Frequency determinations have been demonstrated to be of value in a number of grazing studies (Daubenmire, 1940; Drew, 1947; Gardner & Hubbell, 1943).

Number.--The number of plants entering into the botanical composition of the vegetation on an area is expressed as "abundance", and the number of individual plants per unit area is expressed as "density". Estimates of abundance or density are used for large scale surveys. For detailed studies, the plants are counted in the sampling units, either quadrats (Drew, 1942; Stephens, 1942) or transects (Tinney et al 1937; Hanson, 1934; Vestal, 1943; Brown, 1957).

Since density relationships among species do not change with quadrat size, number of species, or total plant cover, density is a truly quantitative condition and a more reliable characteristic than frequency (Penfound, 1945). However, the chief difficulty in counting plants is the determination of the plant unit, especially in species that propagate by rhizomes or runners. Various definitions of a plant unit as proposed by several workers have been reviewed by Hanson (1950) and Brown (1957).

Area.--Area refers to the amount of the soil surface covered by plants and is expressed in percentage. Cover will vary with the level at which measurements are taken. Therefore, foliage cover and basal cover have been recognized. Basal cover is the amount of the soil surface that is covered by the basal parts of plants, whereas, the vertical projection of the maximum top spread of plants is referred to as foliage cover. Basal cover is more reliable than foliage cover. The following reason for this is given by Brown (1957): "In seasons of plentiful rainfall or seasons of drought, under heavy or under restricted grazing, the base itself, clearly outlined, remains fairly stable in size while

the amount of leaf fluctuates considerably; if the area covered by the base of the plant say, up to 1 inch from the ground, increases or decreases, that can truly be regarded as an increase or decrease in the area of ground covered by the plant, but if the area covered by the foliage increases or decreases that may only be a consequence of higher or lower rainfall or of restricted or severe grazing during that season".

Several methods have been developed for estimating or measuring the area covered by plants. Estimation methods have been used when large areas must be surveyed. The methods dealing with the actual measurements such as: area-list (Murray and Acocks cited by Brown, 1957, and Pearse 1935) and charting by pantograph (Pearse et al 1935), by tripod (Booth, 1943), and by camera (Rowland and Hector, 1934) are difficult and time consuming. The line-interception and point-contact methods require less time than the above methods. The data collected by the line-interception and point-contact methods are used for calculating the percentage composition of the vegetation. The hits recorded by the point method and the number of square centimeters occupied by plants in the line-interception method can be interpreted as frequency. Also, botanical composition on a dry-weight basis can be calculated from the data collected by these methods by using conversion factors based on the dry weight of species. Therefore, these methods have been widely used in vegetation studies. However, each has certain advantages and disadvantages when compared with the other.

Point-Contact Method.—In this method, the sampling unit is a point without any dimensions and the results characterize the vegetation in terms of cover. This method was originated by Cockayne and Levy in New Zealand (Hanson, 1950; Brown, 1957). Cockayne, in studying tussock vegetation, used the toe-cap of a boot and Levy used knots on a tightly stretched string for the points. Present methods were developed by Levy and Levy & Madden (Brown, 1957). The apparatus used consisted of a frame made of two horizontal bars mounted on legs, which were pointed to facilitate pushing into the soil. Ten steel pins were made to move vertically up and down through holes drilled in the horizontal bars. The pins were lowered onto the vegetation and the species which were hit by the points of the pins were recorded. Goodall (1952a) stated that the pins should be as fine as possible because the pin diameter markedly affects the results. The method has been modified with respect to number and spacing of the pins, the height of frame, position of the pins, and the recording of hits. Blackman (1935) showed that readings from single points distributed at random rather than from sets of points gave more accurate representation of vegetation in which species occurred in isolated groups or clumps. Corby (cited by Brown, 1957) stated that a widening of the spacing between the pins on the frame beyond the usual 2 inches reduced the sampling error. The height of the frame is also adapted to the height of the vegetation.

Tinney et al (1937) modified the point-contact method by setting the pins in the frame at an inclination of 45° instead of vertically. Pins

in the vertical position hit flat-leaved species more often than grasses, whereas pins inclined at an angle tend to hit the flat-leaved species less often than grasses. Pins inclined at 45° are more clearly visible in dense vegetation, cover a greater area per reading, and consequently increase the accuracy (Hanson, 1950; Brown, 1957; Vankeuren and Ahlgren 1957a and 1957b). In order to provide sufficient tension on the pins to hold them in any position as desired by the operator, the point frame has been recently modified. Heady and Rader (1958) used leather brakes in the holes and Smith (1959) used clock-spring brakes.

As the pin is moved down either the first hit, all hits, and/or hits at the base of plants are recorded. A pin which fails to touch any plant part, is recorded as bare soil. When only first hits are recorded, there is a tendency for the tall plants to be hit more frequently than low, prostrate ones. When only hits at ground level are recorded, the creeping and prostrate species contribute more to the apparent composition than their actual share (Tinney et al 1937). Drew (1944), and Vankeuren and Ahlgren (1957a and 1957b) obtained greater accuracy by recording all hits rather than only the first hit per pin. The recording of only first hits is, of course, more rapid than the recording of all hits and can be used where less accuracy is required.

When conversion factors were used, some investigators found close relationships between the point determinations and dry weight percentages (Arny & Schmid, 1942; Arny, 1944; Vankeuren and Ahlgren, 1957a, 1957b). Drew (1944) set the pins at an angle of 45° first to the left and then

to the right, and then clipped a rectangular area equivalent to that covered by the vegetation through which the inclined pins passed. He found a good agreement between the relative dry-weights of the species and the number of point contacts with each, without correcting the point readings. However, Arny & Schmid (1942) found great discrepancies in results for the coarse and the fine species. Percentages from point readings were lower for the more bulky species (legumes) and higher for the finer species (grasses) than the percentages determined from dry weights. The differences between grasses were only slight. Furthermore, Arny (1944) and Sprague and Myers (1945) showed that a constant cannot be applied as a correction factor for a species at all stages of its growth. Vankeuren and Ahlgren (1957a and 1957b) calculated correction factors based on the yield per hit and on the regression coefficient between the number of hits and dry weight of species. They concluded that the correction factor based on yield per hit gave more satisfactory results than did the factor based on the regression coefficient.

The point-contact method has been found to be acceptable for large-scale surveys as well as for intensive analyses. Most investigators who have used the method agree that there is a saving of time and labor as compared with other methods. The pin point makes possible the exact distinction between species and consequently reduces the personal factor. Goodall (1952a) suggested that the readings in any series in which comparisons are to be made should be made by the same person. Crocker & Tiver (1948) showed that variation between different observers was high

on windy days. The point-method should not be used on windy days, especially in tall-grass vegetation.

Another disadvantage of this method is that in analyses of area, the total area examined is very small in proportion to the whole area under study.

Line-Interception Method.--This method is a modification of the line transect originated by Bauer (1943). The line-interception method was developed by Canfield (1941, 1944) and proved to be satisfactory for the semi-arid type of vegetation of the southwestern region of the United States not only for botanical analysis but also for measuring utilization. The sampling unit is a line. The linear extent of the basal areas of plants that are intercepted by the vertical plane of the line is measured to the nearest 0.01 foot. From these measurements, the per cent of ground covered and the botanical composition of the vegetation are calculated. The length of the line was 50 feet when the total ground cover was 5 to 15 per cent and 100 feet with 0.5 to 3 per cent cover. Shrubs and half-shrubs were measured on the crown-spread intercept, and the basal cover was measured for grasses and weeds.

Crocker and Tiver (1948) reviewed several survey methods and stated "The line-interception method is of great use in the quantitative analysis of steppe vegetation or fairly open grassland communities."..."In dense swards, however, it is of very limited application, owing to the difficulty once more of recognizing individual plants." However, Anderson (1942) found close agreement in the data secured from the