COMPOSITION AND DENSITY OF THE NATIVE VEGETATION IN THE VICINITY OF THE NORTHERN GREAT PLAINS FIELD STATION

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INTRODUCTION

The grazing industry in the Northern Great Plains area is intimately concerned with the composition and density of the native vegetation. This paper deals with the native vegetation as it exists at present in the section under consideration. While parts of the discussion will apply in general to the Great Plains area, it pertains to western North Dakota and in particular to the territory adjacent to the Missouri River on the west near Mandan. This point lies practically on the one hundred and first meridian and just south of the forty-seventh parallel, north latitude. The Bureau of Plant Industry has one of a number of field stations located here under the direction of the Office of Dry-Land Agriculture. One of the lines of investigation in connection with this station is a grazing experiment in cooperation with the North Dakota State Experiment Station. This investigation is primarily concerned with determining the carrying capacity of the range in that section and working out a grazing system adapted to conditions in the Great Plains. In connection with this work it is necessary to make detailed studies of the native vegetation in order to observe any changes that may occur in the structure of the plant cover. These studies have furnished the material of this paper.[1]

TOPOGRAPHY AND SOIL

The topography of the area around Mandan varies from rolling to nearly level. The land is cut by numerous ravines and coulees, which drain into the Heart and Missouri Rivers. The altitude of the field station is approximately 1,700 feet above sea level.

The following description of the soil of this area is quoted from "The Story of the Prairies" by Willard (*9*),[2] formerly geologist at the North Dakota Agricultural College:

> A belt having an indefinite edge to the westward lies along the west side of the Missouri River, which belt represents the western limits of the glaciated area of North Dakota, and of the Continent of North America. This "belt" of land along the west

[1] The annual reports by the author of the cooperative grazing experiment at Mandan have been frequently referred to and used in the preparation of this paper. These reports are on file in the Office of Dry-Land Agriculture, the North Dakota Agricultural College, and the Mandan Field Station.

[2] Reference is made by number (italic) to "Literature cited," p. 71-72.

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side of the river shows by the character of the soils and the rocks that lie upon or near the surface that the great continental glacier was once here. Toward the west the belt fades out and becomes indistinguishable from the land farther west over which the ice did not pass, but the eastern part of the belt is sufficiently modified as to the soils and the landscape features to be readily recognized.

The soils, therefore, in the belt bordering the Missouri River on the west constitute a transition type from the glacial soils of the eastern portion of the State to the non-glaciated or residual soils of the southwestern portion of the State.

CLIMATE

The United States Weather Bureau Station at Bismarck has made continuous meteorological observations since 1875. Bismarck is located on the east side of the Missouri River, only about 5 miles distant from Mandan. Observations were begun at the Mandan Field Station during 1913. From 1875 to 1914, inclusive, or 40 years, the mean annual precipitation was 17.41 inches. The greatest annual amount during this period was 30.92 inches in 1876, while the lowest was 11.03 inches in 1899. During 1917 the record at the Mandan Field Station was 10.31 inches. The mean seasonal precipitation from April 1 to July 31, inclusive, was 9.91 inches during the 40-year period. The month of maximum precipitation is June, with a mean of over 3.5 inches, and the month of minimum precipitation is February, with less than 0.5 inch.

The temperature is extreme in both winter and summer. The lowest recorded to date was 45° F. below zero in January, 1916, while the highest was 107° above zero in July, 1910 and 1917. The average dates of killing frosts in spring and autumn are about May 15 and September 15, respectively, but frosts have occurred as late as June 7 and as early as August 23. The average frost-free period is 128 days. The prevailing wind direction is from the northwest. The average wind movement near the ground is about 6 miles per hour.

PLANT FORMATION

According to a map of "Plant Formations of the United States," by Shantz and Zon,[1] this region would come within the "short-grass formation." However, Dr. F. E. Clements, who visited the field station during the summer of 1917, is of the opinion that it would be more properly placed in the "long-grass" or "prairie formation," because of the long grasses and other plants which are typical of a prairie formation. From actual determinations in the field the percentages of short-grass and long-grass cover have been found to be nearly equal, so that the formation could be put in either class, according to the viewpoint of the observer. If the secondary plant layer is considered as the determining factor, the region falls in the long-grass formation. The vegetation in this particular area might be considered as in a transition zone, since the dominating species are typical of both formations.

[1] SHANTZ, H. L., and ZON, R. PLANT FORMATIONS OF THE UNITED STATES. Paper presented before the Ecological Society of America at its annual meeting in New York in 1916. The map will appear in the Agricultural Atlas.

The dominating species are *Bouteloua gracilis* (*B. oligostachya*) and *Stipa comata*, which form a distinct association. This is an association composed of *Boutelaua gracilis*, which is typical of the short-grass formation, and *Stipa comata*, which is a typical long-grass species. This association is dominated by the Bouteloua. Sarvis[1] has described in a paper other sections of western North Dakota which show the same dominating species.

COMPOSITION OF THE VEGETATION

In Plate 12 is illustrated the general character of the vegetation on the prairie in the Mandan region. In 1915, when this photograph was taken, the season was very favorable, and all plants reached a maximum development. The composition of the vegetation is thus very clearly illustrated.

In the following list of plants the arrangement of species is in the order of abundance. The order of the primary and secondary species is subject to slight modifications as the studies are extended. The order of the dominant species was determined by measurements from quadrat maps and in the field. The order of the primary species, other than grasses, was determined by count. The secondary species are listed in the estimated order of their abundance.

DOMINANT SPECIES

Bouteloua gracilis	*Carex filifolia*
Stipa comata	*Carex heliophila*

PRIMARY SPECIES

Artemisia gnaphalodes	*Artemisia frigida*
Koeleria cristata	*Stipa viridula*
Solidago pulcherrima	*Eschinacea angustifolia*
Agropyron smithii	*Aristida longiseta*
Artemisia dracunculoides	*Polygala alba*
Psoralea argophylla	*Stipa spartea*
Andropogon scoparius	*Ratibida columnaris*

SECONDARY SPECIES

Muhlenbergia cuspidata	*Aster multiflorus*
Lacinaria punctata	*Petalostemon purpureum*
Calamovilfa longifolia	*Petalostemon candidum*
Agropyron caninum	*Lactuca pulchella*
Bouteloua curtipendula	*Vicia sparsifolia*
Comandra pallida	*Agropyron tenerum*

The grasses, other than the dominant species, are in the estimated order of abundance. It is difficult to make individual counts of them, since they usually occur in bunches. If bunches or mats were considered as single plants and enumerated as such the number would have no significance when compared with that of other plants which usually occur as individuals.

[1] SARVIS, J. T. NATIVE GRASSES OF WESTERN NORTH DAKOTA. Paper presented before the Ecological Society of America at its annual meeting in New York in 1916.

individual plants or between mats and bunches of species which grow in that manner. The term cover (*8*), or ground cover (*5*), is frequently and conveniently used in connection with discussions of vegetation. However, when the term cover is applied in connection with grazing investigations it should be defined, for it may mean one of two things: (1) basal cover, or the ground surface limits of living vegetation, or (2) the foliage cover, which is the plant layers above the basal cover. When the foliage cover is removed, as by close grazing or clipping, the basal cover remains. Plant layers as described by Clements (*1*) are vertical zones based on the height of plants. On the prairie around Mandan two layers are important—the ground layer, as Bouteloua and Carex, and the secondary layer, as Stipa and Psoralea.

Species that grow in mats or in bunches are most accurately expressed in terms of basal cover. For example, Bouteloua basal cover would refer to the amount of ground surface actually covered by Bouteloua if the foliage were removed by grazing or clipping. In such species it is possible to make the determinations with almost mathematical precision. Species that occur as individuals are best expressed in terms of their abundance per unit area. Shantz (7) says in regard to this point:

> Those species which form mats can not be well represented in numbers per square meter, and on this account the percentage of surface covered is given instead.

The foregoing statements in regard to basal and foliage cover are very clearly illustrated in Plate 14. In 1915 the foliage cover was very heavy because growth conditions were favorable and the area had not been grazed. An estimate of the total cover based upon the amount of foliage cover could easily have been made at that time. But in 1916 on the same area, with the foliage cover removed, there would have been no basis for comparison with the 1915 condition. This illustrates the undesirability of utilizing the foliage cover, under all conditions, as a basis for estimating the possibilities of forage production and the consequent carrying capacity. A clear distinction between basal cover and foliage cover is, therefore, necessary and important. The two illustrations of Plate 14 picture the same area, but one illustrates a heavy foliage cover and the other only the basal cover. However, the potential ability of the area to produce under similar conditions as heavy a foliage cover as in 1915 is unchanged.

FIG. 1.—Diagram of grass mat: A, from side; B, from above. *a*, Basal cover; *b*, foliage cover.

Figure 1 illustrates the difference between the basal cover and the foliage cover. The limit of basal growth is *a*, while the limit of foliage growth is *b*. In a given case the surface area of the foliage cover is greater than that of the basal cover, yet the amount of forage is the same. The basal cover is more permanent than the foliage cover, since the latter may be readily removed by grazing. The quadrat map (fig. 2) in the 30-acre pasture, which was mapped in 1915 and remapped in 1916, shows,

with the exception of a few annual species, the basal cover to be practically the same in both years. If the maps had been drawn on the basis of the foliage cover, there would have been a great difference between the 1915 and 1916 maps. The photographs illustrate this difference more clearly than would be possible by quadrat maps. But if the maps are drawn on a basis of the basal cover, various maps of a given quadrat would show actual changes as they occur from grazing. This is really

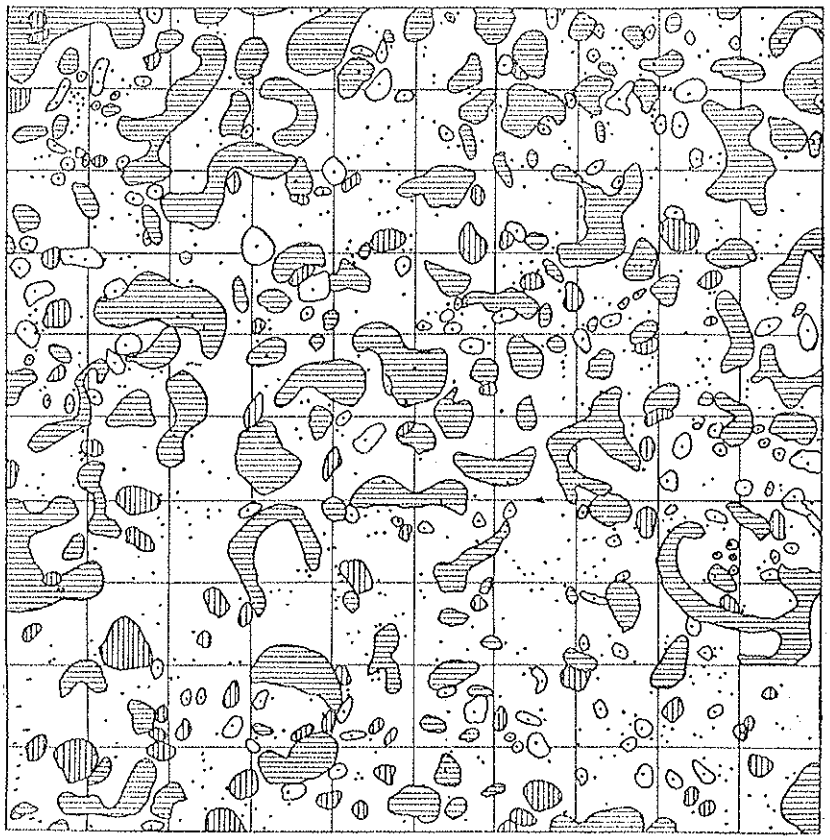

FIG. 2.—Meter quadrat in 30-acre pasture mapped in detail in 1915. Cross hatching represents *Bouteloua gracilis;* vertical hatching, *Stipa comata.* The presence of other species is indicated by dots and outlined areas.

the important point in relation to grazing systems. If grazing has been severe, the basal cover is likely to be changed rapidly, but under normal conditions it should change gradually. This is especially true in such regions as Mandan, where most of the vegetation is made up of perennial species. Sampson (5) says in regard to increase of ground cover:

> The increase in actual stand or ground covered was due almost entirely to the enlargement of the tufts, and text figures 5 and 6 show that even under season-long protection the bunch-grasses and other valuable plants do not increase rapidly by this means.

Since the carrying capacity of the range is largely dependent upon the density of the vegetation, it is obvious that this factor should be carefully determined. If density is determined on the basis of the foliage cover, even when this is possible, the carrying capacity is likely to be placed too high, because of favorable growth conditions or an accumulation of previous growth, and overgrazing will result. In normal seasons the amount of forage a given area of ground surface can produce is largely determined by its basal cover. Therefore, the basis for an estimate of the amount of ground surface covered by vegetation should be founded upon the basal cover. The foliage cover is the important consideration for immediate grazing, but the basal cover more nearly determines the future possibilities of a given area of land for grazing purposes.

AMOUNT OF BASAL COVER AT MANDAN

From quadrat maps drawn to show bare and covered ground surface the total basal cover has been determined. The maps show about 60 per cent vegetated and 40 per cent bare ground. From quadrat maps, such as that in figure 2, made in the various pastures, the percentages of basal cover of Bouteloua and Stipa were determined. These are approximately 20 and 10 per cent, respectively. These determinations were all made from the maps by means of a planimeter.

Shantz (7) has made a number of estimates on the amount of cover in a series of quadrats in the mesa region near Pikes Peak. He has expressed the amounts in percentages in each case. The same method is followed in the present studies. This is a most convenient system, especially when it is desired to express a given species in terms of amount of total cover. Sampson (5) expresses the "density of vegetation" in terms of tenths, using 10 as complete ground cover. In order to avoid confusion, the amounts of cover as used in connection with the Mandan grazing experiment are expressed in percentages.

From the amounts of basal cover of *Bouteloua gracilis* and *Stipa comata* it is readily seen how important they are from the standpoint of grazing in this section. Griffiths, Bidwell, and Goodrich (2) have discussed the value of these grasses for forage. From clipping experiments at Mandan in 1917, in connection with the grazing studies, the Bouteloua was found to have produced from 40 to 50 per cent and Stipa from 15 to 20 per cent of the total forage for the season. When the quadrats were clipped, the vegetation was separated into six parts, as follows: *Bouteloua gracilis*, *Stipa comata*, *Aristida longiseta*, other grasses, *Carex filifolia* and *C. heliophila*, and other plants. Columns are also reserved for the sum of *B. gracilis* and *S. comata* and for the total weight of all grasses and of all species. From these data it is possible to determine the relation of one species or group to another or to the total weight of all species. The various amounts were recorded in grams, weighed both green and air-dried. From these data it appears evident that the ground layer is the important one from the standpoint of grazing in this section.

The abundance of a given species often appears greater than is determined by actual counts per unit area. Pound and Clements (4) have fully discussed this point. From Plate 12 it would appear that *Psoralea argophylla* is the most abundant species. However, by a number of actual counts per unit area it was found to be fourth in abundance of plants other than grasses and sedges.

SUMMARY

(1) The data and conclusions presented in this paper have been obtained in connection with a grazing experiment at the Bureau of Plant Industry Field Station near Mandan, N. Dak. This experiment is designed to determine the carrying capacity of the native vegetation and the effects upon it of different intensities and methods of grazing.

(2) The vegetation is composed of a large number of species, only a few of which produce a considerable amount of the total forage. The dominating species are *Bouteloua gracilis* and *Stipa comata*.

(3) The density of the vegetation is determined by the thickness of plants upon the ground surface and not by the foliage growth. The term cover used in connection with density may mean basal cover or foliage cover. The former remains after the latter has been removed by close grazing or clipping.

(4) The total basal cover of all species in the Mandan region is approximately 60 per cent of the ground surface. *Bouteloua gracilis* has a basal cover of about 20 per cent and *Stipa comata* nearly 10 per cent of the ground surface.

(5) Clipping data of different day periods showed that *Bouteloua gracilis* had produced from 40 to 50 per cent and *Stipa comata* from 15 to 20 per cent of the total forage. The remainder was made up of a number of other species.

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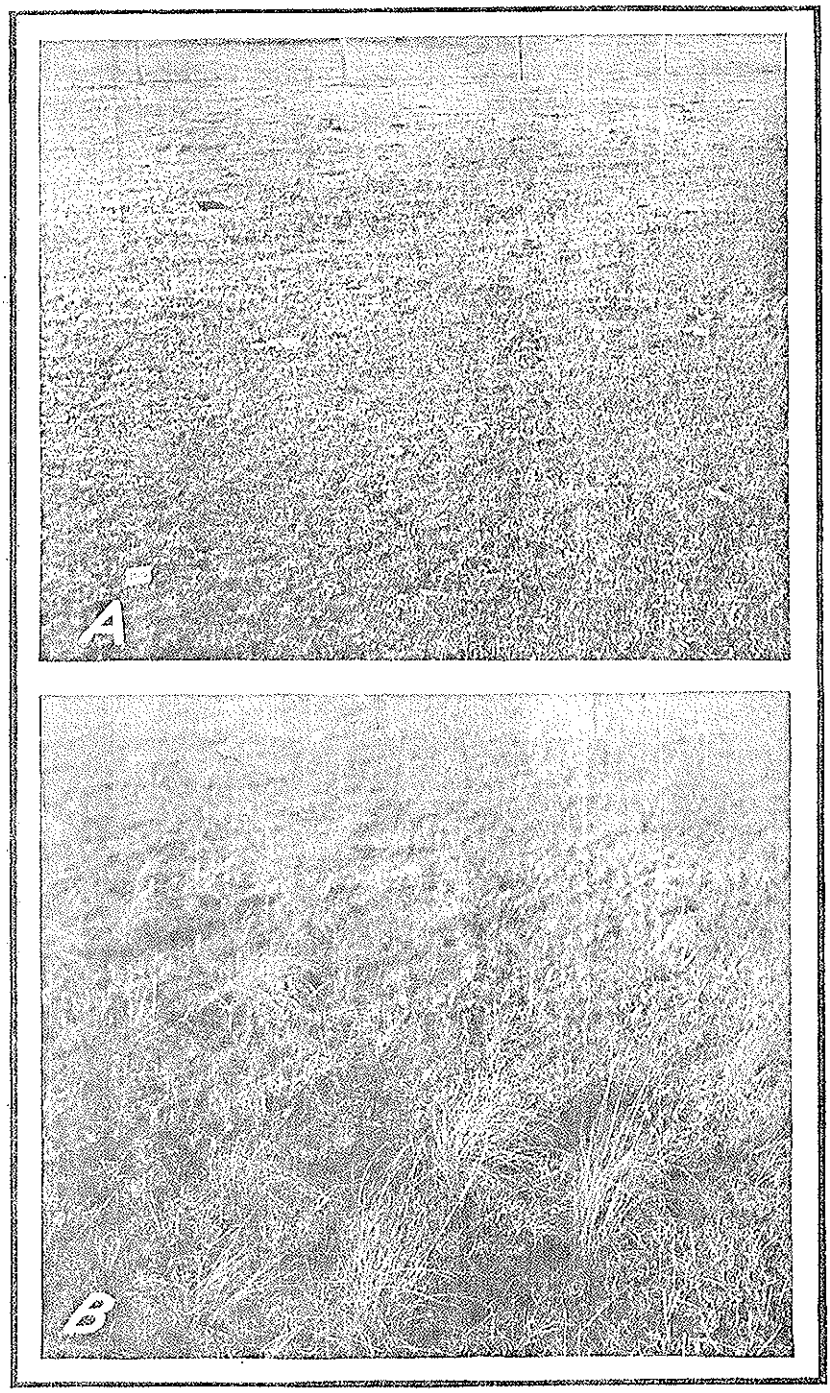

A
B

PLATE 13

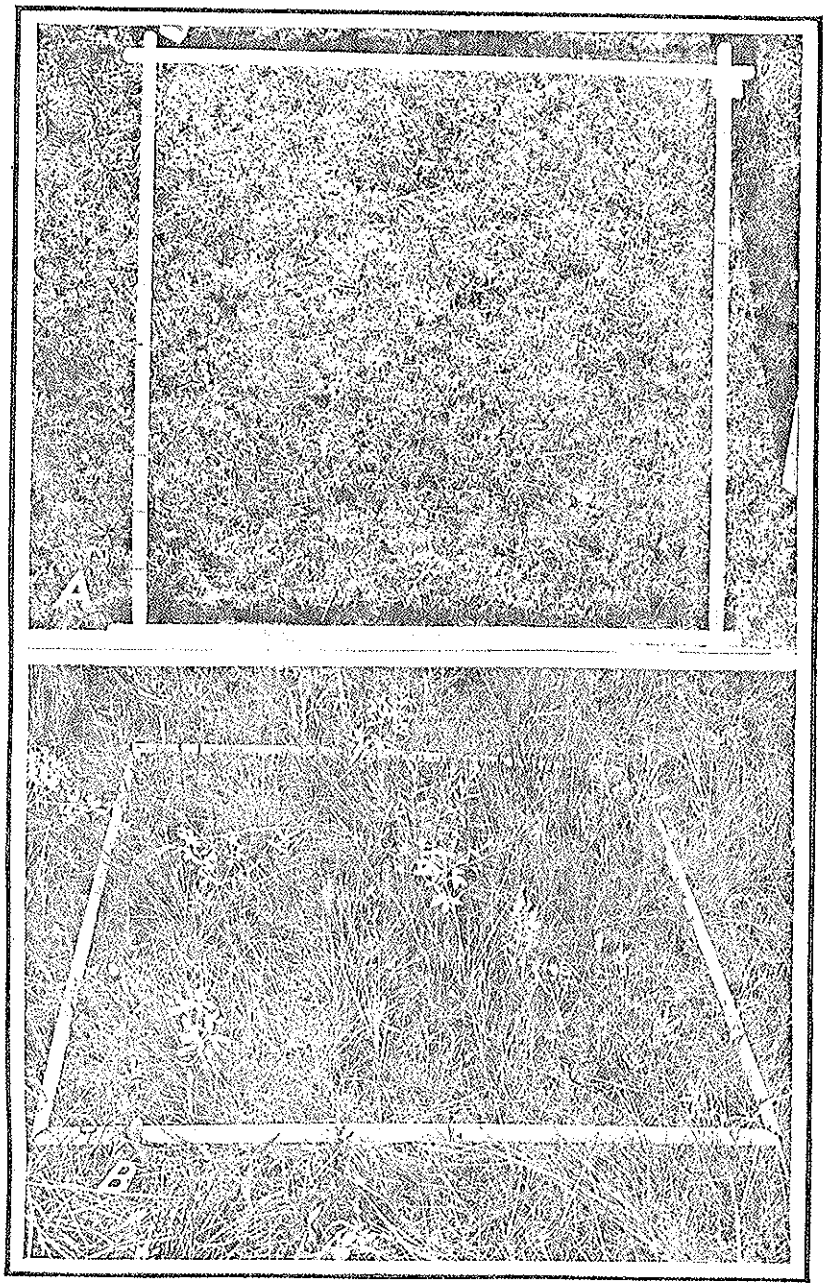
A.—View across area of *Andropogon furcatus*. This grass is closely grazed, as it is greatly relished by cattle. Mandan, N. Dak., Nov. 2, 1917.

B.—Close view of *Aristida longiseta* bunches. All other vegetation has been removed by cattle close to the bunches. Mandan, N. Dak., Nov. 2, 1917.

PLATE 14

A.—Close view, from above, of meter quadrat in 30-acre pasture. This is the same area shown in B but was taken in 1916 after the foliage cover had been removed by grazing. Only basal cover remains. Mandan, N. Dak., Oct. 10, 1916.

B.—Meter quadrat in 30-acre pasture. This shows the cover as it appeared before grazing. Mandan, N. Dak., July 28, 1915.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