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## A Survey of Some Relict Areas of The Great Plains

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FORT HAYS KANSAS STATE

A SURVEY OF SOIL IRRIGATION AREAS  
OF THE GREAT PLAINS

being

A thesis presented to the Graduate Faculty  
of Fort Hays Kansas State College in  
partial fulfillment of the requirements for  
the Degree of Master of Science

by

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July 26, 1957

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## ABSTRACT OF THESIS

A study was made of nineteen relict grassland areas scattered throughout the Great Plains. The study was made to determine basal cover, percentage composition and per cent frequency of the grass and sedge species, and also the soil texture present on these areas. Areas were scattered from Maimi, Texas to Shelly, Montana. The study was conducted during the summer of 1956.

Vegetation was sampled by the square root method as described by Voigt and Weaver (1941). The hydrometer method was used to determine the soil texture. Texture was sampled at depths of six and 24 inches. Climatic conditions present on each area were found in the 1941 U.S.D.A. Yearbook, "Climate and Man".

On a north-facing slope, near Miami, Texas, little bluestem (Andropogon scoparius) was the most abundant grass. Blue grama (Bouteloua gracilis), side-oats grama (Bouteloua curtipendula) silver beardgrass (Andropogon saccharoides) were important species, and western wheatgrass (Agropyron smithii), purple three awn (Aristida purpurea) and hairy grama (Bouteloua hirsuta) made up a minor part of the vegetation. This area had a sandy loam soil in the top six inches and a silt loam soil at a depth of 24 inches.

Across the lowland from the above area, on a

south-facing slope, side oats grama was the most abundant grass. Blue grama and little bluestem were important species, and purple three awn, silver beardgrass and a small Aristida were much less abundant.

Near Mt. Dora, New Mexico, on a loam soil, which terminated at a depth of 20 inches in broken rock, blue grama was by far the most abundant grass. Buffalo grass (Buchloe dactyloides) was found to be an important species whereas galleta (Hilaria jamesii) and ring muhly (Muhlenbergia torreyi) were minor species.

Blue grama was the most abundant species on an area near Pritchett, Colorado. Buffalo grass, the only other grass on the area was somewhat less abundant. Soil in the top six inches was a sandy clay loam, with silt loam being found at a depth of 24 inches.

An area south of Los Animas, Colorado, had loam soil in the top six inches and silt loam soil at a depth of 24 inches. Buffalo grass was the most abundant species while blue grama was less abundant. Ring muhly comprised only a small part of the vegetation.

Blue grama made up a large portion of the vegetation on a silt soil near Hugo, Colorado. Galleta was of much less importance and buffalo grass made up a minor part of the vegetation.

On a sandy loam soil, near New Raymer, Colorado, blue grama was in almost complete control of the vegetation.

Buffalo grass, also present on the area, made up only a small part of the composition.

Near Bushnell, Nebraska, on a sandy loam soil, blue grama made up a large percentage of the composition. Needle-and-thread (Stipa comata) was a less important species. Thread-leaf sedge (Carex filifolia), buffalo grass, western wheatgrass and a species of Aristida made up only a minor part of the vegetation.

An area northeast of Scottsbluff, Nebraska, had a sandy loam soil. Thread-leaf sedge and blue grama were the dominant species. Needle-and-thread was of somewhat less importance.

Needle-and-thread was by far the most abundant species on a silt loam soil east of Chadron, Nebraska. Little bluestem was of much less importance and thread-leaf sedge, plains muhly (Muhlenbergia cuspidata), side-oats grama, June grass (Koeleria cristata), blue grama and western wheatgrass were present in only small amounts.

On a sandy lowland, south of Rushville, Nebraska, needle-and-thread and sand reed (Calamovilfa longifolia) were the dominant species. Sand bluestem (Andropogon hallii) was less important whereas blue grama, little bluestem, June grass and sand dropseed (Sporobolus cryptandrus) were present in only small amounts.

Needle-and-thread and sand reed were also the dominant grasses on top of a sandy dune several miles

north of the above area. Penn sedge (Carex pennsylvanica) and sand bluestem were less abundant. June grass and little bluestem made up only a small part of the vegetation.

Western wheatgrass was the most abundant species on a clay soil southeast of Fairburn, South Dakota. Blue grama was much less abundant whereas thread-leaf sedge and buffalo grass were found to be present in only small amounts.

Near the west end of Cuny Table in South Dakota the top six inches of soil was loam and at a depth of 24 inches a sandy loam. Here thread-leaf sedge was the dominant species. Blue grama was more plentiful than buffalo grass. Sandberg bluegrass (Poa secunda), needle-and-thread and squirreltail (Sitanion hystrix) made up only a minor part of the composition.

Needle-and-thread was the most abundant species on an area near Rapid City, South Dakota. The top six inches of soil was a clay loam with silt loam at a depth of 24 inches. Blue grama was an important species. Western wheatgrass and thread-leaf sedge made up a very minor part of the vegetation.

On an area near Redig, South Dakota, blue grama was the dominant species. Western wheatgrass, needle-and-thread, thread-leaf sedge and June grass were of less importance. Sandberg bluegrass and sand dropseed

were present in only small amounts.

Near Scooby, Montana, on a sandy loam soil Carex spp. and blue grama were the dominant features of the vegetation. June grass was of less importance and western wheatgrass made up a very small percent of the composition.

On an area near Shelly, Montana, the top six inches of soil was a sandy clay loam and at a depth of 24 inches, it was a sandy loam. This area was dominated by western wheatgrass and June grass. Carex spp. and Aristida spp. were of less importance. Sandberg blue-grass and blue grama were present in only small amounts.

Vegetation of relict areas in the Great Plains shows some variation from the south to north as to species present in the composition of this vast grassland. However, some species are found on relicts throughout this entire section of the United States. Blue grama is the most abundant species on ungrazed areas in the Great Plains vegetation.

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## INTRODUCTION

Clements (1934) described climax as an undisturbed community or fragment of one that has survived some important change. This study deals with such relict areas existing in the Great Plains. These undisturbed fragments of grassland represent a treasure chest of information for those studying the nature of the plains climax vegetation. In fact, information from such areas is necessary to judge proper use of grazed lands (Dyksterhuis, 1949). Basal cover and composition are the criteria used to determine the condition and degree of use of ranges.

True relict grasslands are difficult to find. Most relicts are limited to locations such as graveyards, highways, and railroad right-of-ways or to areas made difficult to graze by surrounding farm land or topographic features. Many of these areas are small in size, often containing only a few acres. It was difficult to determine whether there had been any disturbance on some of these areas and, perhaps, some of those studied were not completely undisturbed. However, care was used in selecting only areas where disturbance factors were not apparent.

Most of the studies were made during the summer

of 1956 when the writer had the opportunity to travel through a large part of the Great Plains with Dr. F. W. Albertson of the Botany Department, Fort Hays Kansas State College. Dr. Albertson was conducting a 10,000 mile survey of the Great Plains for the National Park Service. The writer assisted Dr. Albertson and in addition collected data for these studies. The number of undisturbed relicts, even over this large area, was very limited.

The purpose of this study was to collect data pertaining to the vegetative composition and cover of grassland relicts in the Great Plains. Relationships existing between vegetation, soil, climate, and site were also studied.

#### METHODS OF SAMPLING

Relict areas were found by selecting possible locations along the route of travel used in making the survey for the National Park Service. All areas studied were examined for signs of disturbance. The presence of cow chips or sheep droppings, in large numbers, eliminated any area from study. The presence of plants associated with disturbed areas or the presence of obvious disturbance also eliminated areas for study.

Vegetation of all study areas was sampled by means of the square foot as described by Veigt and Weaver (1941). In using this method the worker makes an estimate of the basal cover and per cent frequency in a number of square foot samples. In this case the square foot was constructed of strap iron. Samples of composition and cover were collected at five step intervals, in a straight line. The location of the first sample was at a point where the square foot landed after being tossed in the direction to be traveled. All following locations were found by walking five steps in the selected direction and placing the square foot at the toe of the investigator's shoe.

Samples varied in number on different areas. The least number of samples collected on any area was 20 and the largest was 40. More than 20 samples were collected on areas where the vegetation was not uniform and on areas showing a high number of species.

A spade was used to secure soil samples. Soil was collected at depths of six and 24 inches. These soil samples were stored in round ice cream cartons and texture was determined later by the hydrometer method as described by Bouyoucos.(1936)

All information pertaining to climate was taken

from the Yearbook of Agriculture, 1941, "Climate and Man". Data were obtained from the section "Climate of the States", pages 751 to 1228.

#### RELATED STUDIES

A number of studies of sites scattered through the Mixed Prairie have described the nature of the vegetation on different sites within this association. Some studies were on areas in climax or near climax conditions while others were on grazed grasslands. Studies of grazed grasslands were included to give a more complete picture of the vegetation. Studies are described from south to north to show changes in the vegetation of the Mixed Prairie with relation to location.

Osborn (1950), describing an area near Van Court, Texas, which was not grazed since 1938, listed side-oats grama (Bouteloua curtispindula), Texas needlegrass (Stipa leucotricha), buffalo grass (Buchloe dactyloides), curly mesquite (Hilaria belangeri) and hairy grama (Bouteloua hirsuta) as the major climax grasses of that area on deep upland sites.

Emerson (1932) conducted a study on a rocky soil in the tension zone between the plains and the Pinion-Juniper woodland two miles south-east of Las Vegas, New Mexico. He found blue grama (Bouteloua gracilis), side-

oats grama and buffalo grass to be the important grasses on that area, which was used occasionally for winter grazing. He also found galleta (Hilaria jamesii) to make up a minor part of the composition.

Bruner (1931) describing the Mixed Prairie of Oklahoma, listed little bluestem (Andropogon scoparius), silver beardgrass (Andropogon saccharoides), western wheatgrass (Agropyron smithii), June grass (Koeleria cristata), buffalo grass, blue grama, side-oats grama and hairy grama as the important species of the section. He considered the shorter grasses to be dominant in the panhandle. This description applied to the general area and not to specific locations or sites.

Tomanek and Albertson (1953) described the vegetation of three sites on an area near Hays, Kansas, that had not been grazed since 1900. On the ridgeline they found big bluestem (Andropogon gerardi) to be the dominant grass whereas side-oats grama, little bluestem, blue grama, hairy grama, Indian grass (Sorghastrum nutans), hairy dropseed (Sporobolus pilosus), buffalo grass and three-awn grasses were of less importance. They found big bluestem and little bluestem to be dominant on the hillside and Indian grass, switch grass (Panicum virgatum), side-oats grama, hairy dropseed, western wheatgrass,

blue grama, and hairy grama to be of less importance. On the rocky breaks they found little bluestem to be the dominant grass. Lesser amounts of hairy dropseed, big bluestem and Indian grass were present. All of these sites were on shallow immature soils.

Albertson (1937) studied an area near Hays, Kansas, that had been lightly grazed since 1900. He divided the area into three types. A type dominated by buffalo grass and blue grama was located on an upland site with a mature soil. Other less important species of this type were western wheatgrass, little bluestem, purple three-awn (Aristida purpurea), side-oats grama, prairie sedge (Carex praegracilis), and squirreltail (Sitanion hystrix). A sub-type dominated by buffalo grass and blue grama was also found on lower clay slopes and in clay pockets on the breaks. A second type was dominated by little bluestem and was located on hillsides with thin immature soil containing many rock fragments. Other less important species of this type were big bluestem, side-oats grama, blue grama, hairy grama, switch grass, squirreltail, Indian grass and hairy dropseed. A third type was dominated by big bluestem with side-oats grama western wheatgrass and tall dropseed (Sporobolus asper) being associated with it. This type was found on a lowland site with immature soil.

Stinemetz (1954) described four sites on a study area near Cedar Bluffs Reservoir in Trego county, Kansas. He reported buffalo grass and blue grama to be the major grasses on the upland site. On gentle slopes he found blue grama, side-oats grama and buffalo grass to be the major grasses. On steep slope he reported side-oats grama, blue grama, big bluestem and little bluestem to be the important grasses. In the lowland he found big bluestem, western wheatgrass, switch grass, and side-oats grama to be the important species. This area had very little use for several years.

Weaver and Albertson (1944) reported on the recovery from drought of an area near Hays, Kansas. This area had not been grazed since 1932. They divided the area into four types: short grass, and ecotone between short grass and little bluestem, little bluestem and big bluestem.

Albertson and Weaver (1946) conducted a study on an ungrazed area near Phillipsburg, Kansas. They considered little bluestem, side-oats grama and western wheatgrass to be the chief mid grasses. Big bluestem, Indian grass and nodding wild rye (Elymus canadensis) were the most abundant tall grasses. The major short grasses were blue grama and buffalo grass.

Albertson and Tomanek (1957) conducted a study near Ashland, Kansas, and also near Atwood, Kansas.



They described four sites on each of these areas.

The area at Atwood was located on a fine sandy loam soil of loessial nature. Important species of the upland were blue grama, buffalo grass and side-oats grama. Important grasses of the hillsides were side-oats grama, blue grama and little bluestem. The sharp breaks were dominated by little bluestem and side-oats grama. The major grasses of the lowland were big bluestem, side-oats grama, and western wheatgrass.

Soils of the Ashland area were mostly of a sandy loam texture and were typical Permian Red Bed soils. Albertson and Tomanek found the major species of the upland to be side-oats grama, blue grama, and little bluestem. The hillside was dominated by little bluestem and side-oats grama. Major grasses of the sharp break were little bluestem, side-oats grama and hairy grama. The outstanding grasses of the lowland were big bluestem and side-oats grama.

Albertson and Tomanek (1954) reported on several climax or near climax areas in Weld county, Colorado. They found blue grama, squirreltail, sand dropseed (Sporobolus cryptandrus), western wheatgrass, buffalo grass, needle-and-thread (Stipa comata) and thread-leaf sedge (Carex filifolia) to be the important species on six

ungrazed upland sites having loam soil. On two sandy loam upland sites they found blue grama, western wheatgrass, needle-and-thread and buffalo grass to be the important grasses.

Ramaley (1939) described the vegetation of the sand hill areas in Weld, Morgan, Washington, Sedgewick and Yuma counties in Colorado. This was not a study of ungrazed grassland but it did give a picture of the vegetation existing there.

Costello (1944) described four range types in the Great Plains of Colorado and Wyoming. These types were short grass, dry meadow, sand sagebrush and sagebrush. This study was conducted on well-managed ranges and not on climax areas.

Beetle (1952) conducted a study on an area in Laramie county, Wyoming. This area was located at the north end of Fort Francis E. Warren and had not been grazed since 1900. He reported that Sandberg bluegrass (Poa secunda), June grass, needle-and-thread, thread-leaf sedge and slender wheatgrass (Agropyron trachycaulum) made up the major portion of the vegetation this upland site.

Weaver and Bruner (1948) conducted a study of the vegetation of Dissected Loess Plains between Broken Bow, Ord, Grand Island, Kearney and Lexington, Nebraska.

They divided the vegetation into short grass, mid grass, tall grass and western wheatgrass types. This was not a study of climax conditions.

Hopkins (1951) studied 30 grass areas in the Loess Hills of Central Nebraska. There had been no summer grazing on these study areas but winter grazing had not been uncommon. He divided the study areas into four sites or types. The short grass type was found on hill tops and down the hillside some distance. It was found to be dominated by blue grama and buffalo grass with other species being of minor importance. The mixed grass type was located on hillsides. Important grasses were blue grama, side-oats grama and big bluestem. The mixed mid and tall grass type was located in more mesic areas. Major species were big bluestem, a sedge, and Kentucky bluegrass (Poa pratensis). The wheatgrass type was found to be dominated by western wheatgrass and other species were of minor importance. This type was found where other species had been killed by drought and dusting.

Tolstead (1942) studied the vegetation of the Sand Hills of the northern part of Cherry county, Nebraska. He described the vegetation on seven dry land sites and in the wet meadows. He considered the area to have two major types or sites, the truesand dunes and the tighter

soil. Major species found on dune areas were sand muhly (Muhlenbergia pungens), hairy grama, little bluestem, sand bluestem (Andropogon hallii), sand lovegrass (Eragrostic trichodes) and blue grama. The percentage composition of these and minor species varied with the location on the dune. On the tighter soils he found blue grama, sand dropseed, thread-leaf sedge and needle-and-thread to be the major grasses. This study area had not been grazed since 1914.

Frølik and Keim (1933) studied vegetation of the Sand Hills along the Elkhorn Valley in north central Nebraska. This was primarily a study of hay meadows. They described three types which varied with the water table. The first type was high enough above the water table not to be influenced by it. Major grasses of this community were porcupine grass (Stipa spartea), Bouteloua oligostrachya, and little bluestem. Major grasses of a subirrigated area were Indian grass and big bluestem. A third and still wetter meadow contained prairie cordgrass (Spartina michauxiana), bluejoint grass (Calamagrostis canadensis), plains reedgrass (Calamogrostis neglecta) and Kentucky bluegrass as major grasses. All of the soil was of a loamy sand texture.

Frølick and Shepard (1940) described typical sand hill vegetation in the eastern part of Cherry county,

Nebraska. They divided the area into five vegetative types: dune sand, dry valley, dry meadow, wet meadow and saltgrass. This was not a study of climax vegetation but a survey of typical vegetation under use.

Tolstead (1947) studied the vegetation of the Ponderosa pine woodland in Sioux, Daws and Sheridan counties of Nebraska. He studied the vegetation under three different stands of pines. The major grasses were blue grama, thread-leaf sedge, sun sedge, Kentucky bluegrass, needle-and-thread, and side-oats grama. This study was not conducted on climax areas.

Albertson and Tomanek (1953) made a survey of the Badlands National Monument in South Dakota. They found blue grama, needle-and-thread and buffalo grass to be the important species on rolling mesas. On gentle slopes of mesas they found western wheatgrass and thread-leaf sedge to be the major species. On an isolated butte top they found western wheatgrass, blue grama, and needle-and-thread to be the important species.

Larson and Whitman (1942) conducted studies of grazed and ungrazed areas in the badlands of South Dakota. On Medicine Butte located in the Pine Ridge Indian Reservation near Wanblee, they found western wheatgrass, blue grama, thread-leaf sedge and Penn sedge (Carex pennsylvanica) to be the important species. Near Med-

icine Butte on Little Wolf Table they reported that western wheatgrass, blue grama, needle-and-thread and the sedges mentioned above made up the vegetation. Little Wolf Table had been grazed only intermittently.

Hanson and Whitman (1938) reported on 36 grassland areas free from harmful effects of grazing and mowing. These studies were conducted near Sentinel Butte and Medora, North Dakota. These 36 areas were classified into nine vegetation types. Important species of Type 1 were blue grama, needle-and-thread and thread-leaf sedge. This type was located on upland plateaus and gentle upland slopes with a sand loam soil. Type 2 was dominated by western wheatgrass, blue grama and thread-leaved sedge and was located on long gradual slopes with clay loam soil. The dominant species of Type 3, found on steep slopes with a wide range of soil texture, was little bluestem. Type 4 was dominated by sand reed and was located on sandy ridges. Major species of Type 5 were silver sage (Artemisia cana), western wheatgrass, blue grama and green needlegrass (Stipa viridula). Soil texture of this type varied from clay loam to sandy loam. Type 6 was dominated by saltgrass (Distichlis stricta) and western wheatgrass, and was found on moderately low stream terraces. Type 7 was dominated by saltgrass and alkaligrass (Puccinellis

nuttalliana), and was located on poorly drained areas. Buffalo grass dominated Type 8, located on lower slopes and small draws. The dominant species of Type 9, located on lower slopes with sandy loam texture, was big bluestem.

Heady (1952) described an area on the North Montana Branch Agricultural Experiment Station which had not been grazed since 1915. He listed needle-and-thread as the major species and blue grama, June grass, thread-leaf sedge, western wheatgrass and Sandberg bluegrass as being of less importance. Clubmoss (Selaginella densa) covered 28 per cent of the basal area of this upland site.

Wright and Wright (1948) studied ten relict areas in south central Montana. These ten areas were grouped into five types depending upon the vegetation. Type 1 was located on gravelly loam soil and was dominated by Idaho fescue (Festuca idahoensis). Type 2 was located on gravelly loam soil and was dominated by bluebunch wheatgrass (Agropyron spicatum). This type was located on drier sites than Type 1. Type 3 was located on sandy loam soil with the important species being bluebunch wheatgrass, thread-leaf sedge and blue grama. Type 4 was found on clay loam soil with the major species being blue grama, needle-and-thread, and June grass. Type 5 was dominated by blue grama and needle-and-thread,

and was located on coarse sandy soil which received less moisture than any of the other types.

Coupland (1950) conducted an eight year study of the Mixed Prairie of Canada. The "Stipa-Bouteloua Faciation" was the largest of the divisions and was located on medium-textured soil developed upon undifferentiated glacial till. Major species of this division were needle-and-thread, blue grama and needle-leaf sedge (Carex eleocharis). The "Bouteloua-Stipa Faciation" was located on medium-textured soil formed on undifferentiated glacial till in a drier climate than the "Stipa-Bouteloua Faciation". Major species of this division were blue grama and needle-and-thread, porcupine grass, thickspike wheatgrass (Agropyron dasystachyum), blue grama and needle-leaf sedge. The "Agropyron-Muhlenbergia Facies" was dominated by thickspike wheatgrass and plains muhly (Muhlenbergia cuspidata) with blue grama and needle-leaf sedge being of less importance. This type was found on eroded sloping areas. The "Agropyron-Koeleria Faciation" was found on uniform clay deposits. Major species were thickspike wheatgrass, June grass and needle-leaf sedge. The "Bouteloua-Agropyron Faciation" was located on clay loam soil and was dominated by blue grama and western wheatgrass. Clubmoss made up a high per cent of the basal cover in the Mixed Prairie of Canada.



## RESULTS

Descriptions of relict areas studied and data pertaining to vegetation, soil, and climate were presented here from south to north. This was done to point to the change in species of grass and sedges as one moved from a warmer to cooler climate within the Great Plains.

## MIAMI, TEXAS (NORTH-FACING SLOPE) AREA

Roberts County, Texas, in the panhandle, is the southernmost point from which data were collected. The area studied was located five miles southwest of Miami, Texas, on Texas highway No. 283, two miles north on a gravel road and one mile east along a trail. West of this area was a field of grass which had been reseeded two years before. The southeast and north sides were in contact with native grass range. The general area was a rolling upland.

A small draw head running east and west separated the area into two smaller areas. One of these areas faced south and the other faced north toward the draw. Only data from the north-facing slope is considered here. Data from the south-facing slope is considered under the next heading.

The top layer of soil was a dark sandy loam (Table I).

At a depth of 24 inches the soil, a silt loam, was of a much lighter color. This soil had a granular structure and had chelichie gravel occurring throughout the top 24 inches.

TABLE I. Soil texture on north-facing slope five miles north of Miami, Texas.

Depth	Per Cent Sand	Per Cent Silt	Per Cent Clay	Classification
6"	45.6	48.0	6.4	Sandy loam
24"	22.0	73.6	4.4	Silt loam

Average precipitation in this section of Texas is about 21 inches. Fifteen inches of this comes between April and September. There is an average of 190 days which are free from killing frost. The last killing frost in the spring, on the average, is about April 15. Average July temperature is 74°F. while the average January temperature is 36°F.

Little bluestem was the dominant grass on the north-facing slope (Fig. 1). Blue grama, side-oats grama, and silver beardgrass were important species scattered through the little bluestem (Table II). Blue grama was somewhat thicker in small areas where little bluestem was less dominant. Western wheatgrass, purple three-awn

and hairy grama were also present.

TABLE II. Basal cover, percentage composition and per cent frequency of grass species on a north-facing slope five miles north of Miami, Texas.

Grass Species	Percentage Composition	Per Cent Frequency
Little bluestem	42.50	65
Blue grama	18.00	25
Side-oats grama	15.25	30
Silver beardgrass	12.50	20
Western wheatgrass	5.50	10
Purple three-awn	5.50	15
Hairy grama	.75	5

Basal Cover 24.55 per cent

#### MIAMI, TEXAS (SOUTH-FACING SLOPE) AREA

This area was located across the draw from the area described above. It was part of the same general area but faced south toward the draw with a slope of about five or six per cent.

No soil sample was collected on this site.

Side-oats grama was the dominant grass on this south-facing slope (Table III). Blue grama and little bluestem were important grasses occurring in bunches scattered through the side-oats grama. Purple three-awn, silver beardgrass and a small species of Aristida were less important species.

TABLE III. Basal cover, percentage composition and per cent frequency of grass species on a south-facing slope five miles north of Miami, Texas.

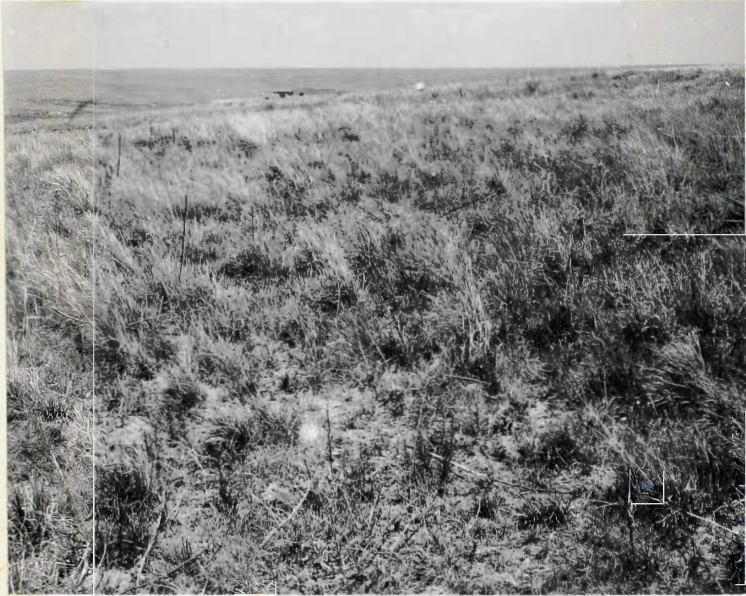


FIGURE 1. Relict area on north-facing slope near Miami, Texas. Dominant grass was little bluestem.

Grass Species	Percentage Composition	Per Cent Frequency
Side-oats grama	42.00	65
Blue grama	30.00	45
Little bluestem	18.00	30
Purple three-awn	8.75	20
Silver beardgrass	1.00	5
Aristida spp.	.25	5

Basal cover 29.1 per cent

In comparing the grasses on the north-facing slope (Table II) and the grasses on the south-facing slope (Table III) one notes that little bluestem and side-oats grama change positions as to their importance in the vegetation. Little bluestem made up 42.5 per cent of the grasses and had a frequency of 65 per cent on the north-facing slope. Side-oats grama, on the other hand, made up 42 per cent of the grasses and had a frequency of 65 per cent on the south-facing slope. Blue grama was of greater importance on the south-facing slope.

#### MT. DORA, NEW MEXICO AREA

This study area was located in northeast New Mexico, 16 miles southwest of Mt. Dora, on the south side of New Mexico highway No. 426. The area was in the fenced right-of-way along the south side of the highway (Fig. 2). Gentle rolling native grassland surrounded the entire area.

This area sloped to the north five or six per cent. The top soil was a dark loam with a blocky columnar struc-

ture (Table IV). No calcium layer was found; however a layer of broken rock terminated the soil at a depth of 20 inches.

TABLE IV. Soil texture on an area 16 miles southeast of Mt. Dora, New Mexico.

Depth	Per Cent Sand	Per Cent Silt	Per Cent Clay	Classification
6"	45.6	23.6	20.8	Loam
20"	Soil terminated in broken rock.			

Blue grama was the dominant grass and occurred in bunches two to eight inches across (Table V). Buffalo grass occurred in small islands scattered through the blue grama. Galleta was found only in favored locations, such as small depressions. Ring muhly was found in rings up to 25 inches across throughout the blue grama. Buffalo grass was of much less importance than blue grama. Galleta and ring muhly made up only a small part of the vegetation.

TABLE V. Basal cover, percentage composition and per cent frequency of grass species on an area 16 miles southeast of Mt. Dora, New Mexico.

Grass Species	Percentage Composition	Per Cent Frequency
Blue grama	68.2	92
Buffalo grass	16.2	24
Galleta	9.6	12
Ring muhly	6.0	20
Basal cover	32.72 per cent	



FIGURE 2. Relict area 16 miles southwest of Mt. Dora, New Mexico. Small, dark-colored clumps in foreground are blue grama and taller light-colored grass was galleta grass.

## PRITCHETT COLORADO AREA

This area was found in a large graveyard in southeastern Colorado. It was one mile north and one mile east of Pritchett, on the south side of U.S. highway No. 160. The area sloped to the north about two per cent. It was surrounded on the west, south and east by cultivation, and contacted the highway on the north. Most of the surrounding area was nearly level and under cultivation.

Top soil was a fairly light-colored sandy clay loam but at a depth of 24 inches the soil was a light-colored silt loam (Table VI). This soil showed some vertical structure in the form of columns. Calcium concretions started at about 12 inches and extended to a depth of at least 24 inches.

TABLE VI. Soil texture of an area one mile north and one mile east of Pritchett, Colorado.

Depth	Per Cent Sand	Per Cent Silt	Per Cent Clay	Classification
6"	49.2	14.8	36.0	Sandy clay loam
24"	25.6	70.8	3.6	Silt loam

The average annual precipitation of this section of Colorado is 16 inches. Twelve inches of this falls from April to September. There is an average of 170 days which are free from killing frost and the last killing frost in the spring, on the average, is on April 30.



The average temperature for January is 33°F.

Blue grama was the dominant grass of the area. (Table VII). Buffalo grass was of less importance but made up almost a third of the vegetation (Fig. 3). These two grasses were mixed throughout the area. It is possible that other grasses may have been found in the area during wetter years but all the grass was in a dormant condition.

TABLE VII. Basal cover, percentage composition and per cent frequency of grass species on an area one mile north and one mile east of Pritchett, Colorado.

Grass Species	Percentage composition	Per Cent Frequency
Blue grama	63.75	95
Buffalo grass	36.25	70
Basal cover 15.1 per cent		

#### LOS ANIMAS, COLORADO AREA

This area was located in southwestern Colorado, 12 miles east and 19 miles south of Los Animas, on the west side of a county road. It was an old graveyard surrounded by three strands of barbed wire. There were a few scattered cow chips indicating at least a small amount of use when range cattle crawled the fence. Native grassland surrounded this upland on all sides. The graveyard sloped to the south about two per cent.

Soil on this area was light-colored and ashy, at least to a depth of 24 inches. The top soil, a loam,



FIGURE 3. Cemetary near Pritchett, Colorado. Blue grama and buffalo grass were the only species found in this area.

was only slightly darker than the silt loam soil at a depth of 24 inches (Table VIII). Calcuim concretions were found at a depth of eight inches.

TABLE VIII. Soil texture of an area 12 miles east and 19 miles south of Los Animas, Colorado.

Depth	Per Cent Sand	Per Cent Silt	Per Cent Clay	Classification
6"	48.8	28.8	22.4	Loam
24"	36.8	58.8	4.4	Silt loam

Average annual precipitation in the section of Colorado near Los Animas is 15 inches. Eleven inches of this falls from April to September. There is an average of 160 frost-free days during the year and the latest killing frost, on the average, is on April 30. Average temperature for the month of July is 77°F. and the average temperature for January is 32°F.

All the grasses in this area were dormant. Buffalo grass was the most abundant grass with smaller amounts of blue grass (Table IX). Ring muhly was found in rings up to 12 inches across scattered through the mixture of buffalo grass and blue grama. Galleta was found in this area but not as a part of the undisturbed vegetation. Galleta was found only on the tops of graves.

Ring muhly was not found in any of the relicts north of this area.

TABLE IX. Basal cover, percentage composition and per cent frequency of grass species on an area 12 miles east and 19 miles south of Los Animas, Colorado.

<u>Grass Species</u>	<u>Percentage composition</u>	<u>Per Cent Frequency</u>
Buffalo grass	63.25	85
Blue grama	27.00	45
Ring muhly	9.75	25
<u>Basal cover 23.3 per cent</u>		

#### HUGO, COLORADO AREA

One area was located in east central Colorado. It was 15 miles east of Hugo, on the north side of U.S. highways No. 40 and No. 287, and on the west side of Colorado highway No. 63 in a triangle formed by the junction of these highways. This area was protected from grazing on two sides by the highways and on the third side by a fence. The area sloped to the southwest about five per cent. Native grassland with gentle rolling topography made up the bulk of the surrounding country.

Soil of the area had a blocky structure. The top soil was a gray silt and soil at a depth of 24 inches was a slightly lighter gray silt (Table X). Small calcium concretions were found at a depth of 24 inches. Rocky Mountain outwash was found scattered through the area.

TABLE X. Soil texture of an area 15 miles east of Hugo, Colorado.

Depth	Per Cent Sand	Per Cent Silt	Per Cent Clay	Classification
6"	5.2	89.6	5.2	Silt
24"	7.6	83.6	8.8	Silt

The average annual precipitation in the section of Colorado around Hugo is 16 inches. Of this amount 12 inches falls from April to September. On the average there are about 140 which are free from killing frost. The latest killing frost, on the average, is on May 10. The average temperature for July is 72°F. and the average temperature for January is 26°F.

Blue grama was the dominant grass on the area (Table XI). Galletta was an important species and buffalo grass made up only a small part of the vegetation. This was the northermost area in which galletta was found.

TABLE XI. Basal cover, percentage composition and per cent frequency of grass species on an area 15 miles east of Hugo, Colorado.

Grass Species	Percentage composition	Per cent frequency
Blue grama	73.25	90
Galletta	18.00	40
Buffalo	8.75	15
Basal cover 14.5 per cent		

#### NEW RAYMER, COLORADO AREA

A fourth study area in Colorado was located in the

northeast part of the state. It was found five miles north of New Raymer in a corner south and west of a gravel road. This corner was formed where the road jogged west, then back north. The south and west sides of this area were protected from grazing by fence. There was also a fence across the road which isolated this area; however there were a few scattered chips showing that cattle moving up and down the road used the area occasionally.

Soil of this area was very light-colored except for the top two inches, which were fairly dark. The top soil was a sandy loam as was the soil at a depth of 24 inches (Table XII). Gravel from Rocky Mountain outwash was present throughout at least the top 24 inches. This soil was composed of very fine granules, except the top two inches, which showed much more structure.

TABLE XII. Soil texture of an area five miles north of New Raymer, Colorado.

Depth	Per cent sand	Per cent silt	Per cent clay	Classification
6"	58.0	22.8	19.2	Sandy loam
24"	62.0	32.8	5.2	Sandy loam

Average annual precipitation in the section of Colorado around New Raymer is 14 inches. Ten inches of the average falls from April to September. There is an average of 140 days during the year which are

free from killing frost. May 15 is the average latest date for a killing frost. The average temperature for July is 71°F. and the average temperature for January is 22°F.

Vegetation was composed almost entirely of blue grama (Table XIII). Buffalo grass was present only in small islands scattered through the much more abundant blue grama (Fig. 4).

TABLE XIII. Basal cover, percentage composition and per cent frequency of grass species on an area five miles north of New Raymer, Colorado.

Grass Species	Percentage composition	Per cent frequency
Blue grama	92.5	95
Buffalo grass	7.5	10
Basal cover 27.95 per cent		

#### BUSHNELL, NEBRASKA AREA

A study area was located in southwestern Nebraska. It was seven miles south of Bushnell on the west side of a gravel road. It was on top of a hill and sloped to the northwest about four per cent. The area sampled was surrounded by native grassland and native hay fields. The general area was rolling to very rolling, with wheat and native grassland occupying most of the land.

This sandy loam soil was light-colored except



FIGURE 4. Relict area five miles north of New Raymer, Colorado. Over 90 per cent of grass cover was blue grama. Scattered plants of prickly pear cactus and four winged saltbrush (Atriplex canescens) were found.



for the top six or eight inches, which were quite dark (Table XIV). The soil was composed of very fine grains. These grains tended to cement together, making this soil hard to penetrate with a shovel down to a depth of about 20 inches. Below 20 inches this soil became quite dry and loose.

TABLE XIV. Soil texture of an area seven miles south of Bushnell, Nebraska.

Depth	Per cent sand	Per cent silt	Per cent clay	Classification
6"	65.2	20.0	14.8	Sandy loam
24"	65.6	29.6	4.8	Sandy loam

The average annual precipitation for the section of Nebraska around Bushnell is 18 inches. On the average, 13 inches of this falls from April to September. There is an average of 140 days free from killing frost, with the last killing frost being on May 10. The average temperature for July is 74°F. and the average temperature for January is 26°F.

Blue grama was the dominant species on this area while other species were of much less importance (Table XV). Needle-and-thread and thread-leaf sedge became a part of the vegetation for the first time (Fig. 5). They were absent in all areas south of this relict. Buffalo grass, western wheatgrass and a small hairy Aristida



FIGURE 5. Relict area six miles south of Bushnell, Nebraska. Note needle-and-thread forming an upper story over blue grama and thread-leaf sedge.

made up a very minor part of the vegetation.

TABLE XV. Basal cover, percentage composition and per cent frequency of grass and sedge species on an area seven miles south of Bushnell, Nebraska.

Grass Species	Percentage composition	Per cent frequency
Blue grama	80.30	100
Needle-and-thread	12.95	50
Thread-leaf sedge	4.50	15
Buffalo grass	1.50	50
Western wheatgrass	.50	5
<u>Aristida</u> spp.	.25	5
Basal cover 49.75 per cent		

#### SCOTTS BLUFF NATIONAL MONUMENT AREA

This relict was located on the Scotts Bluff National Monument in west central Nebraska. An area for sampling was selected on the south side of Nebraska highway No. 85 and east of a small creek. This sample area sloped to the west and varied in slope from two to ten per cent.

Soil of the area was light colored, showing very little structure. The top soil was somewhat granular but below the surface six inches it was composed of very fine grains. The soil was a sandy loam to a depth of at least 24 inches (Table XVI).

TABLE XVI. Soil texture on an area in the Scotts Bluff National Monument in Nebraska.

Depth	Per cent sand	Per cent silt	Per cent clay	Classification
6"	43.6	48.8	7.6	Sandy loam
24"	38.0	52.4	9.6	Sandy loam

Average annual precipitation of the area around Scotts Bluff National Monument in Nebraska is 17 inches. Thirteen inches of this average comes from April to September. There is, on the average, 140 days free from killing frost. The last killing frost on the average is on May 10. The average temperature for July is 72°F. and the average temperature for January is 24°F.

Vegetation of the area was dominated by little bluestem and thread-leaf sedge (Table XVII). Blue grama and needle-and-thread were important. Less abundant species were side-oats grama, June grass, slender wheatgrass, sand reed, and needle grass. On the gentler slopes thread-leaf sedge and needle-and-thread were most abundant. As the slope became greater blue grama increased. On the steep part of the slope little bluestem was very abundant. On a flat not sampled but very near the sampled area slender wheatgrass and green needle grass were dominant.

June grass, slender wheatgrass, sand reed, and green needle grass were found on this area. They were not part of the vegetation on any of the areas south of here. Sand reed perhaps would have been found south of here had some very sandy relicts been sampled (Costello, 1944).

TABLE XVII. Basal cover, percentage composition and per cent frequency of grass species on the Scotts Bluff National Monument in Nebraska.

Grass species	Percentage composition	Per cent frequency
Little bluestem	233.00	50.0
Thread-leaf sedge	31.25	47.5
Blue grama	13.13	30.0
Needle-and-thread	12.13	42.5
Side-oats grama	3.25	5.0
June grass	2.73	22.5
Slender wheatgrass	2.00	2.5
Sand reed	1.13	5.0
Green needle grass	.75	5.0
Basal cover 31.52 per cent		

#### SCOTTSBLUFF NEBERASKA AREA

Another area located in west central Nebraska was 18 miles east and two miles north of the town of Scottsbluff. This area was included in the fenced right-of-way along a gravel road. It was located near a hilltop and sloped about two per cent to the northwest.

The top soil was a dark silt loam (Table XVIII). Soil at a depth of 24 inches was also a silt loam but it was very light in color. This soil had no structure below the top few inches. It was composed of very fine grains to a depth of at least 24 inches.

TABLE XVIII. Soil texture of an area 18 miles east and two miles north of Scottsbluff, Nebraska.

Depth	Per cent sand	Per cent silt	Per cent clay	Classification
6"	52.0	34.8	13.2	Sandy loam
24"	54.8	32.4	12.8	Sandy loam

This area had the same climatic conditions as the Scotts Bluff National Monument.

Vegetation was composed of three species: thread-leaf sedge, blue grama and needle-and-thread (Fig. 6). Thread leaf sedge and blue grama made up most of the vegetation (Table XIX). Needle-and-thread was of less importance than the other species. Thread-leaf sedge covered the ground quite evenly with blue grama occurring in bunches fairly well scattered through it. Needle-and-thread was scattered quite evenly through the two more important species.

TABLE XIX. Basal cover, percentage composition and per cent frequency of grass and sedge species on an area 18 miles east and two miles north of Scottsbluff, Nebraska.

Grass species	Percentage composition	Per cent frequency
Thread-leaf sedge	47.75	95
Blue grama	37.50	90
Needle-and-thread	14.75	30
Basal cover 40.6 per cent		

#### CHADRON, NEBRASKA AREA

This study area was located in northwestern Nebraska,



FIGURE 6. Relict area 18 miles east and two miles north of Scottsbluff, Nebraska. Three principal species were thread-leaf sedge, blue grama and needle-and-thread.

15 miles east of Chadron on the south side of U.S. highway No. 20. It was near a hill top and was surrounded on the west, south, and east by a native hay meadow. On the north side it contacted the highway. Samples were collected from a southwest-facing slope of about six per cent.

Soil of this area was a silt loam; it was light colored near the surface and became very light below the top few inches (Table XX). This soil was composed of very fine grains. Below a depth of eight inches there were numerous small hard clods of soil mixed with the unconsolidated soil particles.

TABLE XX. Soil texture of an area 15 miles east of Chadron, Nebraska.

Depth	Per cent sand	Per cent silt	Per cent clay	Classification
6"	36.0	54.4	9.6	Silt loam
24"	32.4	58.4	9.2	Silt loam

The section around Chadron, Nebraska, has an average annual precipitation of 18 inches. Fourteen inches falls from April to September. There is an average of 140 days which are free from killing frost. The latest killing frost, on the average, is on May 15. The average temperature for July is 71°F. and the average temperature for January is 22°F.

Needle-and-thread was the dominant species (Fig. 7).





FIGURE 7. Needle-and-thread was the dominant grass on this relict east of Chadron, Nebraska. Note bunches of little bluestem in foreground.

Less important species were little bluestem and thread-leaf sedge (Table XXI). Minor species were plains muhly, side-oats grama, June grass, blue grama and western wheatgrass.

TABLE XXI. Basal cover, percentage composition and per cent frequency of grass and sedge species on an area 15 miles east of Chadron, Nebraska.

Grass species	Percentage composition	Per cent frequency
Needle-and-thread	71.83	90.00
Little bluestem	10.16	20.00
Thread-leaf sedge	6.33	10.00
Plains muhly	5.16	6.66
Side-oats grama	2.83	16.66
June grass	1.50	6.66
Blue grama	1.50	10.00
Western wheatgrass	.69	3.33
Basal cover 31.86 per cent		

#### RUSHVILLE, NEBRASKA (FOOT OF HILL) AREA

A study area located in northwestern Nebraska was 15 miles south of Rushville on the east side of a gravel road. It was included in the fenced right-of-way in a rather low area sloping to the east about two per cent from the foot of a hill (Fig. 8). Rolling grassland surrounded the area on all sides.

This area had a very sandy soil which maintained a dark gray color to a depth of at least 24 inches (Table XXII). Because of the high sand content this soil tended to be loose and unconsolidated.



FIGURE 8. Relict area 15 miles south of Rushville, Nebraska. Sand reed and bluestem were dominant grasses on this sandy area.

TABLE XXII. Soil texture of an area 15 miles south of Rushville, Nebraska.

Depth	Per cent sand	Per cent silt	Per cent clay	Classification
6"	89.2	4.4	6.4	Sand
24"	91.6	4.0	4.4	Sand

Average annual precipitation for the section of Nebraska around Rushville is 18 inches. Fourteen inches of this average falls from April to September. On the average there are 140 days free from killing frost during the year. The latest killing spring frost is generally near May 15. The average temperature for July is 73°F. and the average temperature for January is 21°F.

Vegetation of the area was dominated by needle-and-thread and sand reed (Table XXIII). Sand bluestem was an important species. Less abundant species were blue grama, little bluestem, June grass and sand dropseed. Vegetation was quite open on this sandy soil.

TABLE XXIII. Basal cover, percentage composition and per cent frequency of grass species on an area 15 miles south of Rushville, Nebraska.

Grass species	Percentage composition	Per cent frequency
Needle-and-thread	28.33	66.66
Sand reed	28.60	60.00
Sand bluestem	13.50	23.33
Blue grama	5.57	13.33
Little bluestem	5.50	16.66
June grass	4.83	13.33
Sand dropseed	3.67	6.66
Basal cover 14.07 per cent		

## RUSHVILLE, NEBRASKA (HILL TOP) AREA

Another study area was located eight miles south of Rushville, Nebraska, on top of a hill on the west side of the road. Samples were collected on about a three per cent north facing slope. Most of the surrounding area was rolling to very rolling native grassland.

The soil of this area was sandy (Table XXIV). Only the top few inches had much color and it was light gray. This soil was very light at a depth of 24 inches. It had no structure and was held in place only by the vegetation that grew on it.

TABLE XXIV. Soil texture of an area eight miles south of Rushville, Nebraska.

Depth	Per cent sand	Per cent silt	Per cent clay	Classification
6"	93.2	2.0	4.8	Sand
24"	95.2	0.4	4.4	Sand

This area is very near the previous area and has the same climatic conditions.

Needle-and-thread and sand reed were the dominant species (Table XXV). Penn sedge and sand bluestem were important species but much less abundant than the above species. June grass and little bluestem were minor species.

TABLE XXV. Basal cover, percentage composition and per cent frequency of grass and sedge species on an area eight miles south of Rushville, Nebraska.

Grass species	Percentage composition	Percentage Frequency
Needle-and-thread	38.50	60
Sand reed	24.75	60
Penn sedge	15.25	55
Sand bluestem	14.25	40
June grass	6.00	35
Little bluestem	1.25	10
Basal cover 16.5 per cent		

#### FAIRBURN, SOUTH DAKOTA AREA

Another area, found in southwestern South Dakota, was seven miles southeast of Fairburn on the north side of a gravel road. This area was included in the fenced right-of-way along the road and sloped about one or two per cent to the south. Most of this general area was in native grassland except for a small amount of farming along the creeks. It was located at the base of a hill and to the north of a flat extending toward a creek to the south.

The soil on this area was a clay with small gravel mixed through it (Table XXVI). The top soil was dark in color but became much lighter at 24 inches. Gravel present in the soil had been washed from the hills above and deposited with the clay.

TABLE XXVI. Soil texture of an area seven miles southeast of Fairburn, South Dakota.

Depth	Per cent sand	Per cent silt	Per cent clay	Classification
6"	30.0	26	44	Clay
24"	38.4	20	41.6	Clay

The area around Fairburn, South Dakota has an average annual precipitation of 18 inches. Thirteen inches of this falls from April to September. There are, on the average, 140 days that are free of killing frost. The latest killing frost is about May 10. The average temperature for July is 72°F. and the average temperature for January is 22°F.

Western wheatgrass was by far the most abundant species on this area, making up over three-fourths of the vegetation. Blue grama was an important species while thread-leaf sedge and buffalo grass were present in only small amounts.

TABLE XXVII. Basal cover, percentage composition and per cent frequency of grass and sedge species on an area seven miles southeast of Fairburn, South Dakota.

Grass species	Percentage composition	Percentage frequency
Western wheatgrass	77.50	100
Blue grama	18.50	35
Thread-leaf sedge	2.75	15
Buffalo grass	1.25	5

Basal cover 8.35 per cent

## CUNY TABLE SOUTH DAKOTA AREA

An area was studied on top of Cuny Table in southwestern South Dakota. This table is located southwest of the Badlands National Monument. The area studied was located two miles from the west end of the table on the south side of the road. Large areas of this table were farmed at one time but the entire table was used for a target range during World War II. The samples were taken in a large level area on which there had perhaps been but little grazing for a number of years.

Top soil of the area was a dark gray loam while the soil at a depth of 24 inches was a sandy loam and fairly light in color (Table XXVIII).

TABLE XXVIII. Soil texture on an area two miles from the west end of Cuny Table in South Dakota.

Depth	Per cent sand	Per cent silt	Per cent clay	Classification
6"	45.6	36.4	18.0	Loam
24"	52.0	44.4	3.6	Sandy loam

Cuny Table has almost the same climatic conditions as the area near Fairburn. Because Cuny Table rises above the surrounding country there may be some variations in climatic conditions. However, these were not recorded.

Thread-leaf sedge was the dominant species on this



area (Table XXIX). Blue grama was an important species while buffalo grass was much less abundant. Sandberg bluegrass, needle-and-thread and squirreltail were minor species on this area. Of the relicts studied, this was the farthest south that Sandberg bluegrass was found.

TABLE XXIX. Basal cover, percentage composition and per cent frequency of grass and sedge species on an area on the west end of Cuny Table in South Dakota.

Grass species	Percentage composition	Per cent frequency
Thread-leaf sedge	51.25	100
Blue grama	23.50	90
Buffalo grass	12.75	45
Sandberg bluegrass	5.75	25
Needle-and-thread	3.50	20
Squirreltail	3.25	10

Basal cover 42.8 per cent

#### RAPID CITY, SOUTH DAKOTA AREA

A study area was located in west central South Dakota. It was two miles south of Rapid City on South Dakota highway No. 79 and two miles southeast on the south side of a gravel road.

The top few inches of soil on this area were dark in color but soil at a lower depth became lighter. The top soil was found to be a clay loam while the soil at a depth of 24 inches was found to be a silt loam. This soil had a granular structure to a depth of at least 24 inches.

TABLE XXX. Soil texture of an area four miles southeast of Rapid City, South Dakota.

Depth	Per cent sand	Per cent silt	Per cent clay	Classification
6"	28.0	40.0	32	Clay loam
24"	22.8	57.2	20	Silt loam

The section of South Dakota around Rapid City has an average precipitation of 20 inches. Fourteen inches of this falls from April to September. There is an average of 140 days free from killing frost in this section and the latest killing frost is near May 5. The average temperature for July is 70°F. while for January it is 17°F.

Needle-and-thread was the dominant species on this area, making up over two-thirds of the vegetation (Fig. 9). Blue grama made up almost all of the remaining vegetation (Table XXXI). Western wheatgrass and thread-leaf sedge were present in very minor amounts.

TABLE XXXI. Basal cover, percentage composition and per cent frequency of grass and sedge species on an area four miles southeast of Rapid City, South Dakota.

Grass species	Percentage composition	Per cent frequency
Needle-and-thread	68.25	90
Blue grama	31.50	55
Western wheatgrass	.25	5
Thread-leaf sedge	T	5
Basal cover 37 per cent		



FIGURE 9. Needle-and-thread forming an upper story above blue grama six miles southeast of Rapid City, South Dakota.

## REDIG, SOUTH DAKOTA AREA

This study area was located in west central South Dakota two miles east of Redig in a graveyard on the north side of a gravel road. This area was nearly flat except for numerous small depressions. The general area was a flat plain with a few scattered small buttes. Grassland surrounded the graveyard on all sides.

Soil of this area was a light-colored sandy loam near the surface (Table XXXII). Below the top few inches and down to a depth of at least 24 inches the soil was a dark gray silt loam.

TABLE XXXII. Soil texture of an area two miles east of Redig, South Dakota.

Depth	Per cent sand	Per cent silt	Per cent clay	Classification
6"	62.0	28.0	10.00	Sandy loam
24"	40.8	55.2	4.0	Silt loam

Average annual precipitation around Redig, South Dakota is 14 inches. Ten inches of this falls from April to September. There is an average of 130 days during the year which are free from frost and the latest killing frost is about May 20. July has an average temperature of 70°F. while January has an average of 17°F.

Blue grama was the dominant grass (Table XXXIII).

Western wheatgrass, needle-and-thread, thread-leaf sedge and June grass were less abundant while Sandberg bluegrass and sand dropseed were very minor species on this area.

TABLE XXXIII. Basal cover, percentage composition and per cent frequency of grass and sedge species on an area two miles east of Redig, South Dakota.

Grass species	Percentage composition	Per cent frequency
Blue grama	52.75	80
Western wheatgrass	12.75	35
Needle-and-thread	10.75	30
Thread-leaf sedge	9.25	35
June grass	9.25	30
Sandberg bluegrass	4.00	10
Sand dropseed	1.25	10

Basal cover 24.35 per cent

#### SCOBY, MONTANA AREA

This study area was located in northeastern Montana four miles east of Scoby on the north side of Montana highway No. 13. This area was on a flat hill top which sloped slightly to the north and east. The hill broke off rapidly a short distance from the study area. Most of the surrounding country was made up of very rolling native grassland.

Soil of this area was a sandy loam (Table XXXIV). It was fairly dark in the top few inches but became much lighter below this depth. There was some binding of soil particles in the top few inches but at lower

depths there was practically no structure. Glacial rock and gravel of various sizes was found to a depth of at least 24 inches.

TABLE XXXIV. Soil texture of an area four miles east of Scoby, Montana.

Depth	Per cent sand	Per cent silt	Per cent clay	Classification
6"	66.0	25.2	8.8	Sandy loam
24"	72.8	15.4	11.8	Sandy loam

The section of Montana around Scoby has an average annual precipitation of 12 inches. Ten inches of this comes between April and September. There is an average of 120 days during the year which are free from killing frost and the average date of the latest killing frost is May 20. July has an average temperature of 65°F. while the month of January averages 6°F.

Carex spp. made up about one-half of the vegetation (Table XXXV). Blue grama was also quite abundant. June grass was much less abundant while western wheatgrass made up only a minor part of the vegetation.

TABLE XXXV. Basal cover, percentage composition and per cent frequency of grass and sedge species on an area four miles east of Scoby, Montana.

Grass species	Percentage composition	Percentage frequency
Carex spp.	50.50	95
Blue grama	39.00	85
June grass	9.25	25
Western wheatgrass	1.25	5
Basal cover 48.15 per cent		

#### SHELLY, MONTANA AREA

One study area was located in northwestern Montana two miles south of Shelly on the west side of U.S. highway No. 91. This area was located on a northeast facing hillside with a slope of about eight or nine per cent. The area sampled was behind a snow fence where it perhaps received extra moisture (Fig 10.). It was included in the fenced right-of-way. The surrounding country was hilly native grassland.

The top soil of this area was of a gray sandy clay loam (Table XXXVI). At a depth of 24 inches the soil was a sandy loam which maintained the color of the top soil. There was more aggregation of soil particles in the upper few inches.

TABLE XXXVI. Soil texture of an area two miles east of Shelly, Montana.

Depth	Per cent sand	Per cent silt	Per cent clay	Classification
6"	46.0	24.8	29.2	Sandy clay loam
24"	50.8	44.4	4.8	Sandy loam



FIGURE 10. Carex spp. and blue grama were the dominant species behind a snow fence two miles south of Shelly, Montana.



Average annual precipitation of the area around Shelly, Montana is 12 inches. Ten inches of this amount comes from April to September. There is an average of 120 days during the year which are free from killing frost and May 20 is the date of the last killing frost. The month of July has an average temperature of 60°F. while January has an average of 16°F.

Western wheatgrass and June grass were the dominant species of this area, (Table XXXVII). Carex spp. and Aristida spp. were of much less importance whereas Sandberg bluegrass and blue grama were very minor species on this area. Vegetation on this area was quite uniform and the species were evenly mixed with each other.

TABLE XXXVII. Basal cover, percentage composition and per cent frequency of grasses and sedges on an area two miles south of Shelly, Montana.

Grass species	Percentage composition	Per cent frequency
Western wheatgrass	48.0	90
June grass	33.5	85
<u>Carex</u> spp.	9.5	25
<u>Aristida</u> spp.	6.0	20
Sandberg bluegrass	2.0	10
Blue grama	1.0	10

Basal cover 21.4 per cent

#### DISCUSSION

It is not the intention of the author to suggest

that vegetation shown in these studies is necessarily the same as it was before the coming of white man. These areas are now under nearly complete protection. However, before the coming of white man great game herds roamed at will over the plains and exerted varying degrees of influence on the vegetation, depending on the location of water, migration routes, etc. Larson (1940) pointed especially to the effect of bison on that portion of the Mixed Prairie he calls the Short Grass Plains.

These studies present the percentage composition, per cent frequency and basal cover of the vegetation of relicts scattered through the Great Plains at one given time. These factors are subject to change from year to year. Drought probably brings about the greatest change in the vegetation of our native grassland relicts. Weaver and Albertson (1944) and Albertson and Weaver (1946) have mentioned some of these changes occurring in our native grasslands as the result of drought. Study of these relicts does show the capabilities of these sites and soils to produce certain species of vegetation in certain ratios under present climatic conditions. These capabilities should be of great importance to the users of our grasslands.

There is a need for the preservation of area of native grassland in climax conditions. A number of

persons and several organizations have made attempts to establish areas set aside for the preservation of such grasslands. Coupland (1954) pointed to this need and to some of the efforts that have been made to establish areas of grassland maintained in climax condition for study and for the enjoyment of future generations. Some of the organizations making such efforts were the "Ecological Society of America", the "National Research Council", the "Nature Conservatory", the "Grassland Research Foundation" and the "Committee on the Ecology and Preservation of Grasslands". He also listed the presence of 49 first class nature sanctuaries in the United States and Canada, none of which occur in the grassland biome.

There has been much discussion as to the size of a grassland sanctuary. Early suggestions by the "Ecological Society of America" estimated at least 1,000,000 areas should be set aside to include the grassland biome. It is the opinion of this writer, from the grassland research viewpoint, that many small climax grassland areas, scattered through the grassland formation would be of much greater value than a few very large areas. This, of course, would not be true as far as the study of grassland animals is concerned or for recreational values. Smaller areas of perhaps a section or quarter

section, scattered through the grasslands, would be a great aid to research. There should be enough of these areas to include all sites and soils under the various climatic conditions within each state. Information from such research areas would provide a basis for the use of grasslands in that section of the state. For this reason it appears to the writer that a number of small areas would be of more value than a few large areas.

This survey of relicts in the Great Plains brings to one's attention several features of the vegetation in this section of the United States. Data are perhaps too limited to draw any definite conclusions; however, there are several features of the vegetation which appear to be quite evident.

Blue grama is the most abundant grass on ungrazed areas in the Great Plains. It made up an average of 36 per cent of the composition on the 19 relict areas sampled. It was absent only on one very sandy relict. Blue grama generally occurred with a mixture of other grasses but on an area near New Raymer, Colorado it made up 92 per cent of the composition.

Buffalo grass is not a major grass on relict areas of the Great Plains. It was found on only eight of 19 relicts sampled and tended to be more abundant on relicts in Colorado than in any other section. It

was found on only two of the 11 areas north of Bushnell, Nebraska, and there only in small amounts. This would perhaps indicate that under climax conditions, buffalo grass is primarily a grass of the southern half of the Great Plains.

Little bluestem and side-oats grama seem to be somewhat associated with each other. Little bluestem was found on six of the 19 relicts studied while side-oats grama was found only on four relicts and each time it was associated with little bluestem.

Western wheatgrass was more abundant on relicts to the north. It was not an important species except on two relicts. Western wheatgrass made up 78 per cent of the composition on one area where the soil had a high clay content.

Needle-and-thread is an important feature of the vegetation north of New Raymer, Colorado, being present on nine of the 12 relicts north of that point. However, in only one case did it make up over half of the composition.

Thread-leaf sedge is an important part of the vegetation north of New Raymer, Colorado. Thread-leaf sedge was absent on only one of the 12 relicts north of New Raymer. It made up over half of the composition on two of those areas.

June grass was found only on relicts studied

north of Bushnell, Nebraska. Even here it did not make up a high percentage of the composition except on the area near Shelly, Montana, where it made up 34 per cent of the composition. This area was near a snow fence and was perhaps more mesic than the surrounding country.

If one were to make a division of the Great Plains into northern and southern portions, on basis of these 19 relicts sampled, it would seem to fall in the general area of New Raymer, Colorado. South of New Raymer galleta, silver beardgrass, hairy grama and ring muhly were found. However, they were absent north of there on all relicts. Buffalo grass also was much more abundant south of New Raymer. North of New Raymer needle-and-thread and thread-leaf sedge become an important part of the vegetation but were absent on all relicts sampled south of there. June grass and Sandberg bluegrass were present on some of the relicts north of New Raymer but were absent on all areas south of there. Western wheatgrass, a cool season grass, became a much more apparent feature of the vegetation north of New Raymer. It seems to this writer a division of the Great Plains, north and south, as to grass species could be made at this point.

## SUMMARY

The purpose of this study was to find the soil texture and the nature of the vegetation existing in relict areas in different parts of the Great Plains. Nineteen areas were studied and they were scattered from Miami, Texas to Shelly, Montana.

A study of the basal cover, per cent composition and per cent frequency of the major grasses was measured by the use of the square foot method. Soil texture was determined by the hydrometer method.

Vegetation of relict areas in the Great Plains shows some variation from the south to north as to species present in the composition of this vast grassland. Blue grama (Bouteloua gracilis), and buffalo (Buchloe dactyloides) were the dominant species in relict areas studied in the southern half of the Great Plains. Little bluestem (Andropogon scoparius), side-oats grama (Bouteloua curtipendula), silver beardgrass (Andropogon sacchardoides), galleta (Hilaria jamesii), ring muhly (Muhlenbergia tarreyi) and Aristida spp. were present on some of the areas. In fact, little bluestem and side-oats grama were each dominant on a relict area studied near Miami, Texas. Blue grama, needle-and-thread (Stipa comata) and thread-leaf sedge (Carex filifolia) were the dominant

species on relict areas studied in the northern half of the Great Plains. Western wheatgrass (Agropyron smithii) was also dominant on a few areas. Buffalo grass, little bluestem, side-oats grama, June grass (Keeleria cristata), slender wheatgrass (Agropyron trach-coulum), sand reed (Calamovilfa longifolia), green needle-grass (Stipa viridula), plains muhly (Muhlenbergia cuspidata), Sandberg bluegrass (Poa secunda) and squirreltail (Sitanion hsytrix) were found on some relicts in the north half of the Great Plains.

Blue grama was by far the most abundant grass on relicts in this survey of the Great Plains. It was present in all but one of the areas studied and was the dominant species in most of them.



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