RETROGRESSION OF NATIVE RANGE VEGETATION IN THE SANDY HIGH PLAINS

BY

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CHAPTER I

INTRODUCTION

Due to its location and inadequate roads, the High Plains of Oklahoma historically was an isolated area. Before settlement this region was on the cattle-drive routes between Texas and Kansas. With the coming of railroads and the ending of transient grazing, many large ranches were established.

Today, approximately one-half of the land remains under native grass cover. Casual observations made over the past several years have indicated a change in the vegetation to a less desirable type.

Many factors of disturbance such as over-use, fire, droughts, and erosion have changed the orderly succession of the grass communities and have caused retrogression on many of the native range lands. The various steps by which change from climax vegetation occurs has not been determined for the High Plains Area of Oklahoma. Bruner (1931) described the southward extension of the mixed prairie through Oklahoma and its relations to true prairie and short grass plains. An excellent discussion was presented by Shantz (1911) on the short grass plains of eastern Colorado. Albertson (1937) studied the ecology of the mixed prairie in west-central Kansas. According to Dyksterhuis (1949) a knowledge of the range vegetation affords a scientific basis for planned range improvement. Tomanek and Albertson (1953) found a definite reduction in the amount of vegetation and the vigor of the plants on heavily used areas in their studies of range land near Hays, Kansas. They indicated that additional studies were needed on range conditions of various types.

Range condition studies need to be made in order that a relationship between range condition and beef production can be established. According to McCorkle and Heerwagen (1951) those ranches with range conditions that averaged good marketed 5.4 pounds more beef per acre than did those in poor condition. Although mankind has had a long history of soil exploitations through grazing or other land use practices, this condition does not need to continue. Range lands can be grazed indefinitely according to Humphrey (1962) without depleting the range resources. The ability to use the range without reducing its productivity depends primarily on an understanding of the principles involved in plant production and secondarily on the application of those principles.

The primary purpose of this study was to determine the extent of retrogression that has occurred to the native range vegetation in the High Plains of Oklahoma. The study was limited to the sandy plains range sites located in the northeast portion of Beaver County.

CHAPTER II

REVIEW OF LITERATURE

Need for Additional Studies

Grazing returns could easily be doubled in America Savage (1951) reported if only the currently available information on range and pasture management and improvement were utilized. An increase of even greater magnitude would be possible through further and more comprehensive research on all phases of range and pasture improvement and plant development. Many research people have studied the trend of retrogression as it occurred on our ranges. Ellison (1960) was concerned with retrogression in his studies of plant succession of range lands. Probably one of the first studies of retrogression was by Sampson (1919) in his investigation of plant succession in relation to range management. The changes associated with retrogression are the primary factors determining range condition. The major factors considered in this paper were density of the vegetation, composition of the vegetation, litter or mulch on the ground, and stability of the soil.

The changes associated with retrogression have been studied by numerous researchers. Sampson (1919) reported after thirteen years of study in the western United States, that the most rational and reliable way to detect overgrazing is the ability to recognize the replacement of one type of plant cover by another. Equally as important was his conclusion that the grazing value of the vegetation is essentially determined by the stage of succession. Generally the carrying capacity and forage value are highest where the vegetative cover represents the stage in close proximity to the herbaceous climax and lowest in the type most remote from the climax.

A study of range vegetation is concerned with the fundamental reasons for the differences in yields of different ranges or of the same ranges at different times. The primary concern is with average current yield and average potential yield. It was pointed out by Dyksterhuis (1956) that knowledge of the site, its climax, and secondary succession in range evaluation enables one to visualize vegetation beyond current plant communities and to predict changes that will tend to restore equilibrium in the ecosystem. When studying a range, one should ask the question, "What is happening here"?

Different types of plant communities are affected differently by grazing pressure or other disturbances. Tomanek and Albertson (1953) described the pattern of retrogression in Kansas and found that total basal cover of the vegetation increased with an increase in grazing pressure. The ranges with heavy grazing pressure had only about one-half as many plant stems per unit area as the lightly grazed areas. They reported the increase in basal cover resulted from the increased amount of short grass under greater grazing pressure on all sites.

Grazing created tremendous changes in the vegetation of western Kansas. On two areas of mixed prairie, Tomanek and Albertson (1957) found that grazing caused a decrease in the mid and tall grasses and a proportional increase in short grasses. On some areas of upland 40 percent of the ungrazed prairie was formed by mid and tall grasses, but this amount was reduced to 22 percent under moderate grazing. Under heavy grazing pressure the mid and tall grasses were reduced to 5 percent. In a study near Ashland, Kansas, buffalograss (Buchloe dactyloides)[1], increased from 5 percent to 90 percent with heavy grazing pressure. An increase in basal cover due to excessive grazing is not true in all cases. Johnston (1962) and Kemmedson (1956) found that basal cover decreased with deterioration in range condition.

Kucera (1956) charted the trend of retrogression in virgin prairie of north central Missouri and found that decreaser plants, mostly Andropogon gerardi and A. scoparius comprised an estimated 68.5 percent of the total vegetative cover on lightly used pastures. The percentage cover for these same species in the heavily grazed areas was reduced to 5 percent. Andropogon scoparius which constituted 46 percent of the total herbaceous cover was reduced to 3 percent by grazing. The deterioration of the prairie grass was accompanied by a reciprocal increase of invader species. Kucera (1956) attributed the drastic reduction of Andropogon gerardi and A. scoparius and the increase of increaser and invader species to heavy livestock concentration.

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[1] Scientific names follow Waterfall, U.T., 1960. Keys to the Flora of Oklahoma.

Forage production on heavily utilized pastures often was less than half as much as from moderately grazed pastures (Tomanek and Albertson, 1957). Similar results were found by Launchbaugh (1955) in his analysis of vegetative retrogression in the San Antonio Prairie. As grazing intensity was increased, the percentage of decreasers declined. Andropogon scoparius was reduced from 68 percent to less than 3 percent of the grass composition. The percentage of increaser plants rose from 30 percent in the lightly grazed pastures to approximately 80 percent in the moderately heavy grazed pastures. Overgrazing resulted in an increase in invaders from a trace in the lightly grazed pasture to nearly 40 percent in the heavily grazed pasture.

Importance of Mulch to Range Condition

The storage of rainfall at the grass roots places the moisture precisely where it belongs, where it can be most readily converted into grass, and subsequently into meat and dollars. Humphrey (1962) pointed out that it behooves the range manager to strive toward more efficient water intake since the amount of precipitation is an important, and perhaps the most important single factor that determines the kind of plant community that will dominate a region under natural conditions.

Kemmedson (1956) suggests that the indication of soil disturbance and instability such as erosion pavement, plant pedestalling, bare soil, and degree of litter cover become more evident as ranges deteriorate.

The rate of water intake on range land increases with an increase in the amount of standing vegetation or natural mulch. Johnston (1962) found the removal of cover by excessive grazing resulted in the creation of an artificially droughty condition. Soil moisture was less, and soil temperatures were greater on the very heavily grazed pastures than those on the more moderately grazed areas.

Robinson, Blaser, and Peterson (1957) revealed through testing of water absorption that the infiltration rate on the moderately grazed pasture was nearly twice (2.28 inches per hour) that of heavily grazed ranges (1.18 inches per hour). Similarly, the amount of soil erosion occurring with each inch of surface runoff was nearly twice as high from heavily grazed ranges (263 pounds an acre) as from moderately grazed acres (121 pounds per acre).

In order to maintain maximum infiltration of rainwater, Dyksterhuis and Schmutz (1947) concluded that living plants must be supported by a layer of natural mulch; consequently, one may expect retrogression in grassland communities when the natural mulch is not adequate.

CHAPTER III

LOCATION AND DESCRIPTION OF STUDY AREA

Location

The area and each location selected for study lies in the northeast part of Beaver County between the North Canadian and Cimarron Rivers as shown in Figure 1 and is classified as a sandy plains range site by the USDA Soil Conservation Service. Figure 2 depicts a typical sandy plains range site.

Topography and Drainage

The rolling topography is typical of the area with slopes from three to twelve percent. Many dunes, sharp ridges, deep ravines, and natural drainage ways are present. The drainage is about equally divided between the North Canadian and Cimarron Rivers. The altitude of the area is approximately 2500 feet.

Soils

The soils are mapped as Otero-Pratt fine sandy loam complex with three to twelve percent slopes. This complex consists of seven soils: namely, Otero, Pratt, Tivoli, Lincoln, Likes, Mansker and Potter.

Figure 1. A partial map of Beaver County, Oklahoma, showing the Sandy Plains Range Site and location of each study area.

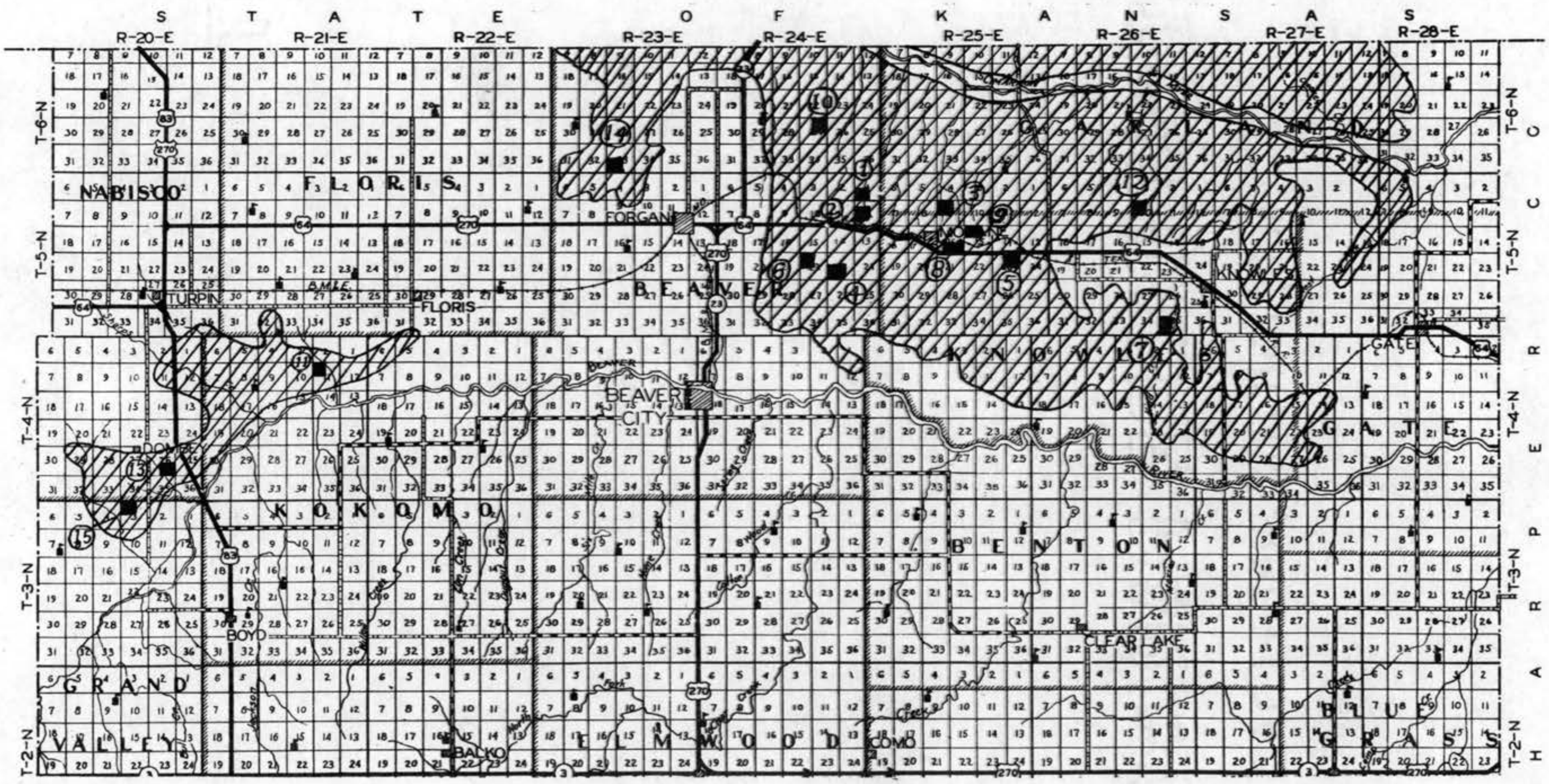


Figure 2. A typical sandy plains range site. An Otero-Pratt soil complex. Sideoats grama and blue grama are in the foreground. Buffalograss may be seen in the top right. Sagebrush is scattered throughout the site. This area is about 5 miles north of Mocane, Oklahoma.

The Otero soil makes up about 65 percent of the complex and the Pratt about 30 percent. The remaining 5 percent consists of the other five soils mentioned above. The soils may be briefly described as follows:

The Tivoli series consists of deep, loose, structureless, sandy materials. These soils are droughty, however the loose, porous soil material absorbs water rapidly, and little moisture is lost through runoff or evaporation.

The Lincoln soils consist of deep, sandy materials that are forming in recently deposited alluvium. They are unstable because new material is deposited on them by floodwaters. Flooding leaves fresh sand and loamy deposits on the surface; consequently, vegetation has little time to become established.

The Likes soils consist of loose, calcareous, sandy material that in this area are primarily on the concave foot slopes of the sandhills. These soils occur below the Tivoli, Otero, and Pratt soils and above the alluvial soils on the lowlands. They take in water rapidly, but in dry seasons they are droughty because their capacity for storing moisture is low.

The Mansker series consists of gray-brown, calcareous, loamy soils that have a high lime subsoil. Runoff is moderate to rapid, depending on the slope and vegetation. Permeability is moderate in the upper layers but is slow in the lower layers.

The Potter soils are stony and have a thin surface soil. The surface layer is a gray-brown clay loam about 5 inches thick. Beneath this layer is a hard, rocklike, fractured caliche. Permeability in the Potter soils is fair in the upper few inches; however, the caliche substratum impedes penetration of water and plant roots.

A description of an Otero and Pratt soil is given in Tables I and II respectively (Allgood et al., 1962). Figure 3 is an aerial photograph of the study area showing a typical Otero-Pratt soils complex.

General Climatic Conditions

The study area has a dry, mild, continental climate which is characterized by extremes and rapid changes in temperature and precipitation. The average frost-free period is approximately 198 days. The average date of the last killing frost in the spring is April 5, with October 20 being the date for the first in the fall. About 72 percent of the average annual precipitation falls between April and September. The weather record for Beaver, Oklahoma, as shown in Table III was compiled from records of the United States Department of Commerce, Climatological Data. The 1964 precipitation and temperature readings are reported in Table IV.

TABLE I. A DESCRIPTION OF A TYPICAL PROFILE OF AN OTERO SANDY LOAM SOIL.

A_1 0 to 6 inches, grayish-brown (10YR 5/2) sandy loam, dark grayish brown (10YR 4/2) when moist; weak, medium, granular structure; many roots; large amount of organic matter; loose when dry; friable when moist; slightly calcareous; gradual boundary.

AC 6 to 16 inches, pale-brown (10YR 6/2.5), slightly cohesive loamy sand, brown (10YR 5/3) when moist; moderate, coarse, prismatic and weak, medium, granular structure; loose when dry, friable when moist; strongly calcareous; gradual boundary.

C 16 to 38 inches, very pale brown (10YR 7/3.5) loamy sand, light yellowish brown (10YR 6/4) when moist; single grain (structureless); loose when dry, friable when moist; strongly calcareous.

The Otero soils take in water rapidly but have a low available moisture-holding capacity. They are droughty because their subsoil lacks fine-textured material that would store the moisture. The soil is highly susceptible to wind erosion.

Lime in the substratum may be in the form of films or soft caliche, or it may be mixed in the weakly consolidated sand. Concretions of calcium carbonate make up as much as 20 percent of the soil mass.

TABLE II. A DESCRIPTION OF A TYPICAL PROFILE OF PRATT FINE SANDY LOAM SOIL.

A_1 0 to 12 inches, dark yellowish-brown (10YR 4/4) fine sandy loam, dark yellowish-brown (10YR 3/4) when moist; weak, fine to medium, granular structure; soft when dry, very friable when moist; noncalcareous; plowed boundary.

B_2 12 to 32 inches, yellowish-brown (10YR 5/4) fine sandy loam, dark yellowish-brown (10YR 4/4) when moist; contains about 5 percent more clay than A_1 horizon; weak, fine to medium, granular structure; noncalcareous; gradual boundary.

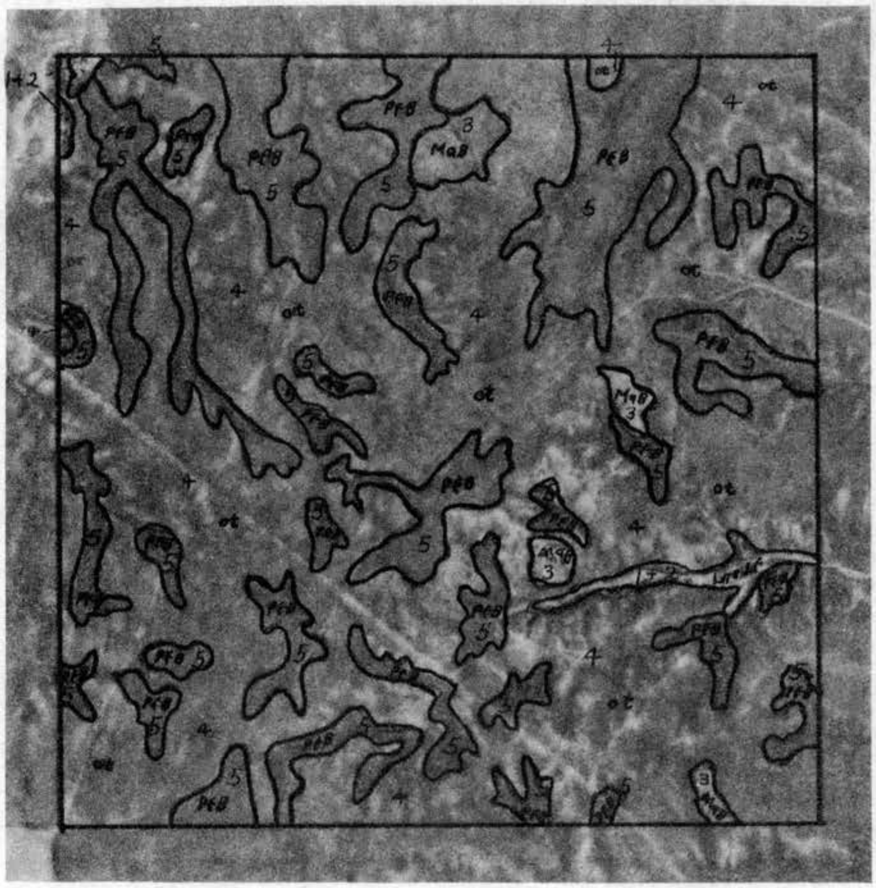
C_1 32 to 40 inches, light yellowish-brown (10YR 6/4) loamy fine sand containing thin lenses of sand, yellowish-brown (10YR 5/4) when moist; weak, granular structure; soft when dry, very friable when moist; noncalcareous; gradual boundary.

C_2 40 to 54 inches, light yellowish-brown (10YR 6/4), medium and fine sand, yellowish-brown (10YR 5/4) when moist; single grain (structureless); loose; noncalcareous.

The Pratt soils consist of deep, rapidly permeable, moderately sandy material. Water penetrates this soil rapidly, and its good moisture holding capacity favors the growth of plants. It has little runoff except during intensive rains. The soil is highly susceptible to wind erosion.

These soils are noncalcareous in the A_1 and B_2 horizons, but in a few places they are weakly calcareous below a depth of 30 inches.

Figure 3. Aerial photograph showing a typical Otero-Pratt soils complex.



Legend

Number	Symbol	Soil Series
1	Lf	Likes
2	Ln	Lincoln
3	MaB	Mansker
4	Ot	Otero
5	PfB	Pratt

TABLE III. CLIMATOLOGICAL DATA FOR BEAVER, OKLAHOMA

(ELEVATION, 2,560 FEET)

	Temperature[1]			Precipitation[2]			
Month	Average	Absolute maximum	Absolute minimum	Average	Driest year (1933)	Wettest year (1941)	Average snowfall
	F.	F.	F.	Inches	Inches	Inches	Inches
December	35.3	84	-16	0.77	-.40	0-46	4.0
January	33.3	82	-20	0.46	0.03	0.87	3.1
February	37.0	90	-19	0.76	0.16	1.57	4.1
Winter	35.2	90	-20	1.99	0.59	2.90	11.2
March	46.9	101	-12	0.97	0.15	1.70	3.5
April	56.8	102	10	1.91	0.62	2.99	0.4
May	65.8	107	22	2.67	1.26	5.67	Trace
Spring	56.5	107	-12	5.55	2.03	10.36	3.9
June	75.7	112	37	3.88	0.36	5.07	Trace
July	81.4	111	46	2.09	0.75	4.01	Trace
August	80.3	115	41	2.39	5.07	3.09	0.0
Summer	79.1	115	37	7.36	6.18	12.17	Trace
September	71.9	110	29	2.06	0.01	2.64	Trace
October	59.0	97	13	1.50	0.54	6.77	0.5
November	45.3	94	-1	0.90	0.68	0.49	1.4
Fall	58.7	110	-1	4.46	1.23	9.90	1.9
Year	57.4	115	-20	19.36	10.03	35.33	17.0

[1]Average temperature based on 59-year record, through 1955; highest and lowest temperature on a 54-year record.

[2]Average precipitation based on a 59-year record, through 1955; wettest and driest years based on a 48-year record, in the period 1899-1955; snowfall based on a 54-year record, through 1952.

TABLE IV. CLIMATOLOGICAL DATA FOR 1964 AT BEAVER, OKLAHOMA.

Month	Temperature		Precipitation		
	Absolute Maximum	Absolute Minimum	Inches	Snowfall Inches	Days Ground Covered
January	76	-4	0	0	0
February	63	9	1.35	9.5	13
March	82	13	0.06	0.5	1
April	91	25	0.02	*Severe dust storm	
May	99	40	2.63	0	0
June	100	43	3.37	0	0
July	109	54	1.76	0	0
August	110	51	1.31	0	0
September	101	36	1.01	0	0
October	94	30	0.09	0	0
November	82	15	0.13	0.25	1
December	71	-3	1.54	11.0	11

*April 12 - Total darkness from 1:30 P.M. to 2:00 P.M.

CHAPTER IV

MATERIALS AND METHODS

Selection of Study Area

The sandy plains range sites of northeastern Beaver County were chosen to study the pattern of retrogression in this part of the High Plains. The basis for this slection was its size and importance and the fact that it has always been range land. For our purpose in this paper the term range will indicate only native pasture on natural grazing land. Fifteen study areas were selected which would best show the change and degree of retrogression or vegetative departure from the climax composition. An effort was made to locate relict areas which would reflect the climax vegetation for the area and site. Probably no true relict areas are available for study, however, two reasonably large areas were found on which very little disturbance had occurred.

Methods of Measurement

The point intercept method of vegetative analysis (Levy and Madden, 1933; Brown, 1954; Crockett, 1963) was used to determine the percent basal cover; percent relative composition; and percent frequency of the grasses and forbs on each study area.

The sampling apparatus used as shown in Figure 4 consisted of an aluminum metal frame containing ten sliding pins located at three-inch intervals and inclined at a slight angle. The frame is placed down at predetermined intervals and each species contacted by a point is recorded. In this study, only the basal contact method was used. A species was recorded only if it was in contact with the point at ground level.

Samples were taken at equal distances along a predetermined transect line. The size and length of the plot determined the distance between samples since it was planned to take 200 sets or 2000 points per study area.

Basal cover, or the percentage of the ground surface covered by the vegetation of each species was estimated by the formula:

$$\text{Basal Cover} = \frac{\text{Number of hits for each species}}{\text{Total number of points}} .$$

Percentage composition was used as a measure of the relative importance of the several species in the total vegetative cover. The relative composition was estimated by the formula:

$$\text{Relative Composition} = \frac{\text{Number of hits for each species}}{\text{Total number of hits for all species}} .$$

Frequency of species occurrence, expressed in percent, was used as a measure of the dispersion of a species on a pasture. The frequency of species occurrence was estimated by the formula:

$$\text{Frequency} = \frac{\text{Number of quadrats in which a species occurs}}{\text{Total number of quadrats}} .$$

Figure 4. An inclined point quadrat with ten sliding pins used in this study for vegetative analyses.

The amount of mulch present on each range condition class was determined by collecting all mulch from twenty (11½ by 24 inch) quadrats. The mulch on one non-grazed area was also collected. Both attached and detached mulch was measured. The detached mulch lying on the ground was collected first, after which the attached mulch was clipped.

Each species was clipped and weighed separately. The individual samples were dried at 100° centigrade for 36 hours and the weights were recorded in grams. Pounds of mulch per acre were calculated by multiplying the average weights in grams by the factor of 50.

CHAPTER V

RESULTS AND DISCUSSION

Non-grazed Study Areas

In order to demonstrate the change in plant composition from the climax, several non-grazed areas were studied. There is academic justification in any skepticism of the term relict area, therefore, for the purpose of this study the original vegetative composition was determined to be essentially as that of selected non-grazed areas.

In this study the primary concern was with the original vegetation and the changes that have occurred primarily as the result of grazing pressure.

Three types of non-grazed areas were examined: namely, railroad rights-of-way, cemeteries, and other non-agricultural areas. The railroad rights-of-way seemed to be the most reliable, therefore, they were used as the basis for study of the original vegetation.

The rights-of-way have been under continuous fence since the railroad was constructed in 1914. No apparent man-made disturbances have occurred during the past fifty years.

"Because of their frequency, continuity, and relatively early date at which they were fenced railroad rights-of-way surpass every other source of relicts in the middle west," stated Clements (1934).

Other areas, such as an abandoned grass plot within a large ranch, were also selected for study of the original vegetation. One such area had not been grazed since 1907; however, it was not considered equal to the rights-of-way for this study.

Detailed surveys were made on these two non-grazed areas, and the percentage composition of grasses and forbs is shown in Table V. A general view of the railroad rights-of-way may be seen in Figure 5. A slightly more detailed view is shown in Figure 6, showing the type and density of the vegetation. Buffalograss (Buchloe dactyloides), sideoats grama (Bouteloua curtipendula), and blue grama (B. gracilis) were the principle grasses in the area.

Several species of forbs that did not appear in the survey were present in very limited amounts: dotted gayfeather (Liatris punctata), heath aster (Aster ericoides), wild alfalfa (Psoralea tenuiflora) bear grass (Yucca glauca), cutleaf goldenweed (Haplopappus spinulosus), camphor weed (Heterotheca latifolia), (H. subaxillaris), and hairy gold aster (Chrysopsis villosa).

RANGE CONDITION AND GRASS COMPOSITION

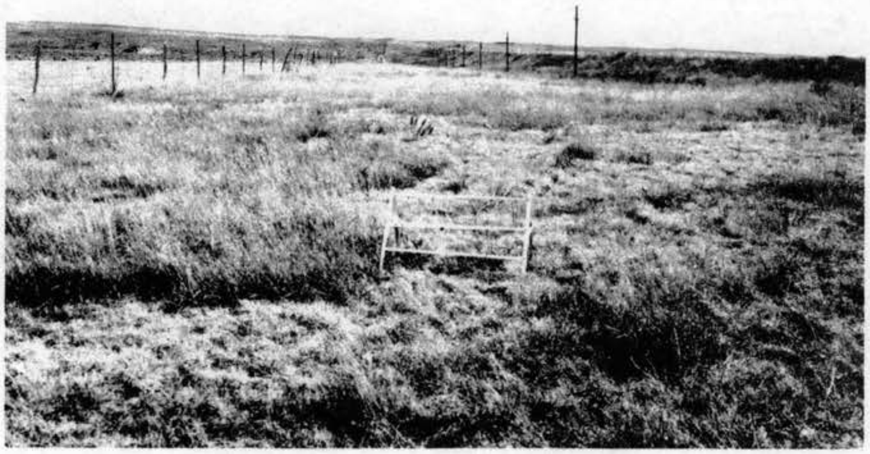
Range Condition Class

The range condition class is an arbitrary classification indicating the present vegetation in relation to the plants that made up the original vegetative cover for that site.

TABLE V. RELATIVE COMPOSITION, EXPRESSED IN PERCENT OF THE VARIOUS SPECIES OF GRASSES FOUND GROWING IN THE TWO NON-GRAZED AREAS.

Species	Plant Composition in Percent	
	Area No. 16 Railroad Rights-of-way	Area No. 17 Non-agricultural Area
Buchloe dactyloides	54.0	38.0
Bouteloua curtipendula	27.0	34.0
Bouteloua gracilis	15.0	24.0
Sporobolus cryptandrus	1.2	1.2
Bouteloua hirsuta	1.7	1.0
Aristida purpurea	1.1	1.0
Liatris punctata		1.0
Total Decreasers	27.0	34.0
Total Increasers	73.0	66.0
Average Decreasers for both study areas	30.5	
Average Increasers for both study areas	69.5	

Figure 5. A general view of the railroad rights-of-way.



The above view of the railroad rights-of-way is approximately one and one-half miles east of Mocane, Oklahoma. Photo was taken in August, 1964. The area was fenced in 1914. Sideoats grama, buffalo-grass and blue grama are the main grasses. The area is relatively free from invader grasses and forbs.

Figure 6. A detailed view of the railroad rights-or-way area.

A close-up photograph of the vegetation as it appeared in the railroad rights-of-way in August, 1964. Sideoats gramagrass is the taller vegetation in the center of the photograph. Buffalograss is the dense, low growing material in the upper right of the picture. Blue grama although difficult to point out clearly is growing in the lower left corner.

The most abundant and important range plants have been grouped into classes according to the manner in which they respond to grazing. Those plants that made up the original vegetation on the range land are called climax plants.

The first class of plants is called decreasers. The decreasers are climax plants which will give way to less desirable plants under heavy grazing. The second class is called increasers. The increasers are climax plants which will increase during the period the decreaser plants are being grazed out and then will themselves decrease under continued heavy grazing. The third class is called invaders. The invaders are low quality plants which thrive on disturbed areas and will invade the site when climax plants are grazed out or are low in vigor.

To show the degree of retrogression, the fifteen study areas have been arranged into three range condition classes: namely, good, fair, and poor. A general view of a good range condition class in the sandy plains range site is shown in Figure 7. In Figure 8 a fence line contrast shows the sharp transition between good and fair range condition classes. A general view of a fair and a poor range condition class is shown in Figures 9 and 10 respectively.

Grass Composition

A definite retrogressive trend can be seen in the grass composition as a result of disturbance by grazing.

The total plant composition of the 15 pastures studied is shown in Table VI. The decreaser grasses comprised 43.1 percent of the

Figure 7. A general view of a good range condition class. Photo was taken in August, 1964. Note the abundance of unused forage which furnished an excellent soil mulch. Vigor of vegetation is excellent and erosion hazards are at a minimum.

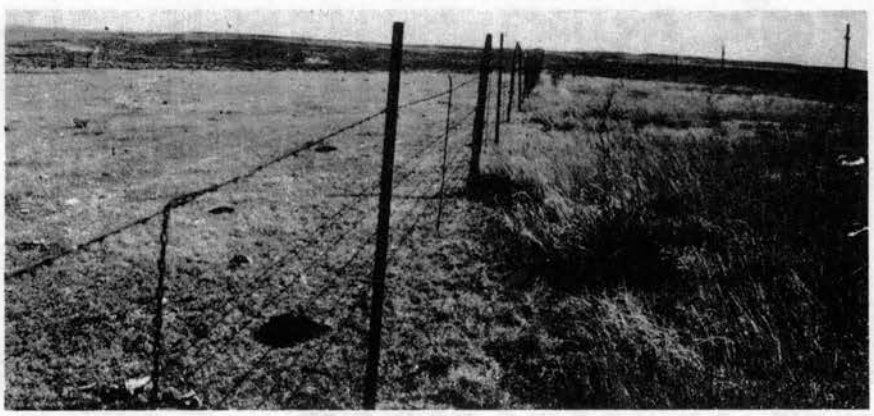


Figure 8. A fence line contrast showing the abrupt transition from a fair range class (on left) to a good range condition class (on the right). Composition of the vegetation was studied on both sides of the very narrow ecotone. Photo was taken in August, 1964. Area on the right is the non-grazed area that has not been disturbed by grazing since 1914.

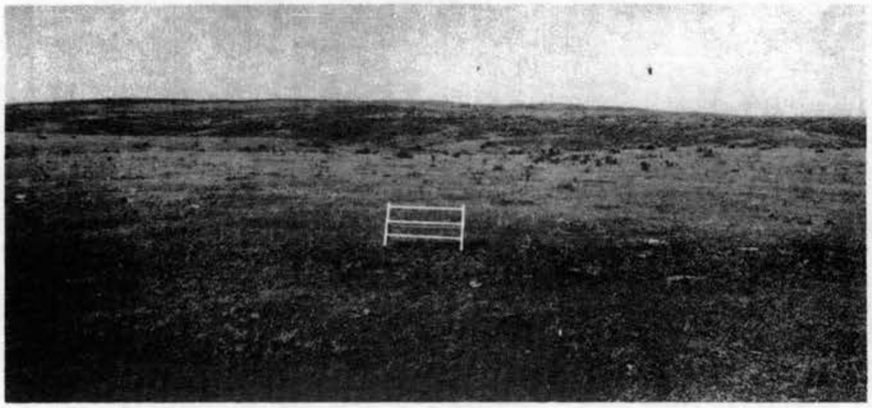


Figure 9. A general view of a fair condition range class. This view shows uniformly close grazing at 1.5 to 2 inches over entire range. All available forage has been consumed.

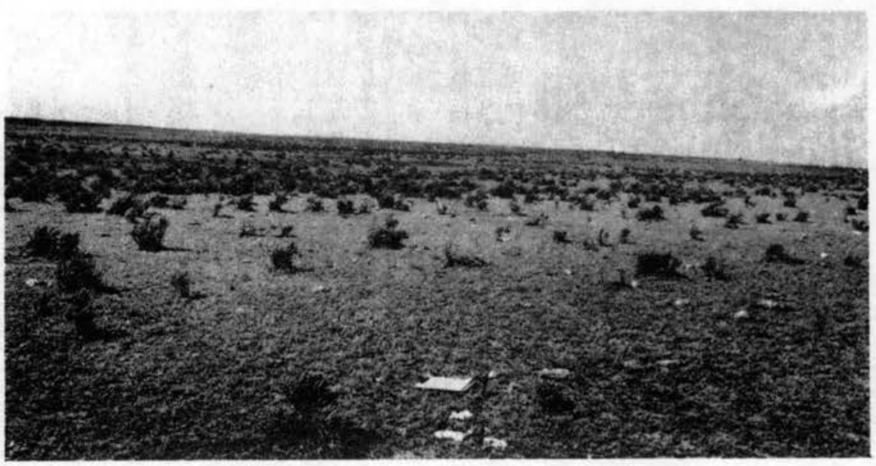


Figure 10. A general view of a poor condition range class. Note the apparent lack of vigor. Bare ground is exposed, indicating past heavy use. The roughness or bunchy appearance of the area is due to the pedestalling of the grasses. This photo was taken in August, 1964.

TABLE VI. RELATIVE COMPOSITION EXPRESSED IN PERCENT OF DECREASERS, INCREASERS, AND INVADER GRASSES AND THE PERCENT BASAL COVER.

	Study Areas														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Decreasers	43.1	32.7	31.0	35.8	41.9	26.0	25.3	20.4	25.5	15.3	2.0	14.1	2.6	6.4	11.2
Increasers	46.9	63.6	53.8	54.1	52.1	68.9	68.7	72.0	70.3	78.7	93.1	78.4	92.5	88.9	83.9
Invaders	1.2	1.2	2.0	4.3	2.3	1.1	0.5	0.8	1.9	0.8	0.1	2.5	0.4	0.6	2.9
Basal Cover	29	39	34	34	40	46	36	30	36	61	34	38	30	35	34
Average of Basal Cover	35.2					41.8					34.2				
Range Condition	Good					Fair					Poor				

vegetation in study area number 1, and decreased to 2 percent in area number 11. The increaser grasses ranged from 63.6 percent in study area number 2 to 93.1 percent in number 11. By comparing one area of good vegetation with another, or one fair, or poor with another, it becomes evident that the percentage composition in similar classes is very much the same although the areas are widely separated.

The average percentage composition of the grasses by classes and species in each range condition class is shown in Table VII. These figures represent the averages of 1000 quadrats for each class. The differences in the percentage of decreaser grasses in good or fair range condition class compared to a poor is very noticeable ranging from 36.8 percent in the good to 7.3 percent in the poor. Conversely, the increasers became more abundant. In the same sequence the percentages were 53.9 to 84.6 percent as shown by the good to poor range condition comparisons respectively.

The relative composition of decreaser, increaser, and invader grasses found in the fifteen study areas is shown in Figure 11. These figures compare very favorably with those reported by Weaver and Tomanek (1951) in a study of midwestern ranges.

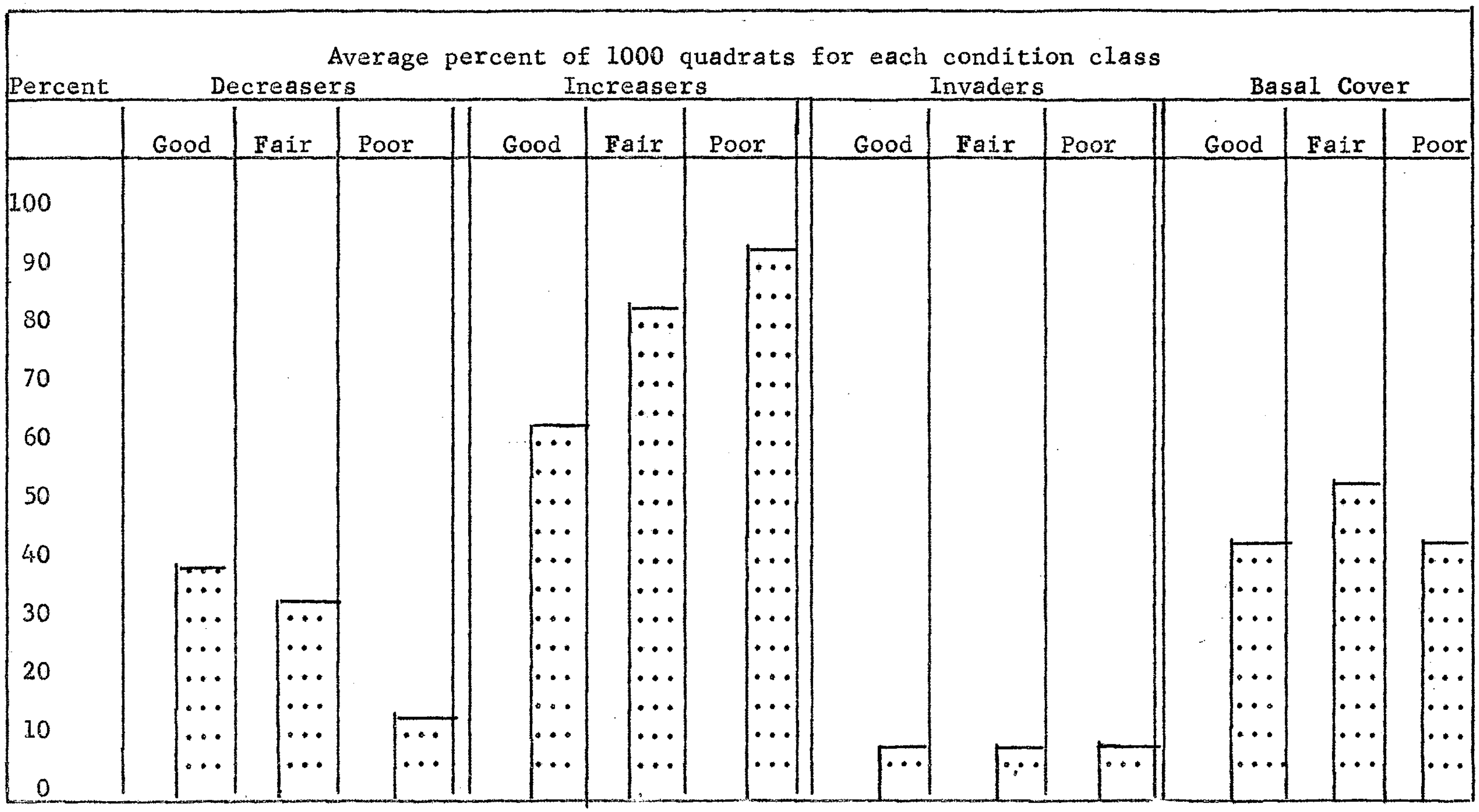
Basal Cover

The average basal cover of the vegetation in the good area was 35.2 percent as compared to 34.2 in the poor condition study area as shown in Table VI. Voigt and Weaver (1951) have shown that the basal cover in a poor range condition area decreased with the opening of the cover.

TABLE VII. PERCENTAGE COMPOSITION OF THE VEGETATION IN EACH RANGE CONDITION CLASS. THE FIGURES ARE THE AVERAGES OF 1000 QUADRATS FOR EACH CLASS TAKEN IN AUGUST, 1964.

	Range Condition Class		
	GOOD	FAIR	POOR
DECREASER SPECIES		Percent Composition	
Andropogon scoparius	2.3	0.04	0.5
Andropogon halli	0.4	----	0.9
Panicum virgatum	0.08	0.04	---
Bouteloua curtipendula	33.9	22.1	5.9
Agropyron smithii	0.02	----	---
Calamovilfa gigantea	0.08	0.02	---
Panicum obtusum	----	0.2	---
Total	36.78	22.40	7.3
INCREASER SPECIES			
Bouteloua gracilis	3.9	5.4	23.9
Buchloe dactyloides	26.9	41.1	45.6
Sporobolus cryptandrus	11.2	16.0	11.7
Paspalum stramineum	0.4	---	0.2
Aristida purpurea	0.2	0.3	0.06
Bouteloua hirsuta	11.3	8.7	2.8
Andropogon saccharoides	---	0.2	0.3
Total	53.9	71.7	84.56
INVADER SPECIES			
Chloris verticillata	1.0	0.3	0.5
Schedonnardus paniculatus	0.3	0.04	0.1
Aristida longiseta	0.9	0.6	0.6
Eragrostis spp.	0.06	0.02	---
Tridens pilosus	---	0.06	0.04
Munroa squarrosa	0.02	---	0.08
Total	2.28	1.02	1.32
FORBS	7.04	4.88	6.82
Grand Total	100.00	100.00	100.00

Figure 11. Relative composition, expressed in percent of decreasers, increasers, invaders and basal cover in the good, fair, and poor condition ranges.



Decreaser Grasses

Sideoats grama was the most abundant species of the decreasers. This grass averaged 33.9 percent of the total composition in the good condition pastures, 22.1 percent in the fair condition pastures, and 5.9 percent in the poor condition class. The decreasers, sand bluestem, switchgrass, and sand reedgrass were present in very limited amounts on all areas. These tall grasses were found only on the Pratt soils of the Otero-Pratt soil complex. The amount of these grasses in the study areas seemed to be in proportion to the amount of Pratt soils in the range site. Little bluestem was present in the Otero soils in very limited amounts, and then it would usually be found growing only on some type of soil disturbance such as an old road, cattle trail, or gulley. Deposits of sand and silt from nearby fields or roads onto the Otero-Pratt soil complex seemed to create conditions that were favorable for the tall grasses. On area number 1, the tall grasses constituted 7.6 percent of the grass composition. This was the highest amount found in any of the study areas.

Increaser Grasses

Of the seven species of increaser grasses, buffalograss, blue gramagrass, hairy gramagrass (Bouteloua hirsuta) and sand dropseed (Sporobolus cryptandrus) were the most important. The amount of sand dropseed in the good range class and in the poor was identical. A slight increase was noticed in the fair condition class. Probably the competition from the vigorous growing grasses in the good condition class kept sand dropseed at a minimum, whereas in the fair condition class the competition was not heavy enough to limit its growth. Heavy grazing pressure in the poor range condition class probably was responsible in keeping this species from increasing. Hairy grama is another grass that depended to some degree on the soil type. It was rather abundant on the shallow soils of the steeper slopes. Figure 12 shows a general view of the vegetation on these shallow soils on which the dominant grass is hairy grama. The increaser grasses increased from 53.9 percent in the good range class to 84.6 percent in the poor condition class. A study of Table VII shows that the rapid gains of the increasers from an average of 53.9 percent in the good class to 71.7 and 84.6 percent in the fair and poor classes respectively, closely parallels losses by the decreasers. These results are similar to those reported by Weaver and Tomanek (1951) in their studies of a midwestern range. The decreaser grasses diminished progressively from good range condition to poor while the increaser grasses increased as the range condition deteriorated.

Along with these grasses were limited amounts of sand paspalum (Paspalum stramineum), purple threeawn (Aristida purpurea) and silver bluestem (Andropogon saccharoides).

Invader Grasses

Invader grasses consisted mainly of the threeawn grasses (Arisida spp.), windmill grass (Chloris verticillata), tumblegrass (Schedonnardus paniculatus), hairy tridens (Tridens pilosus) and false

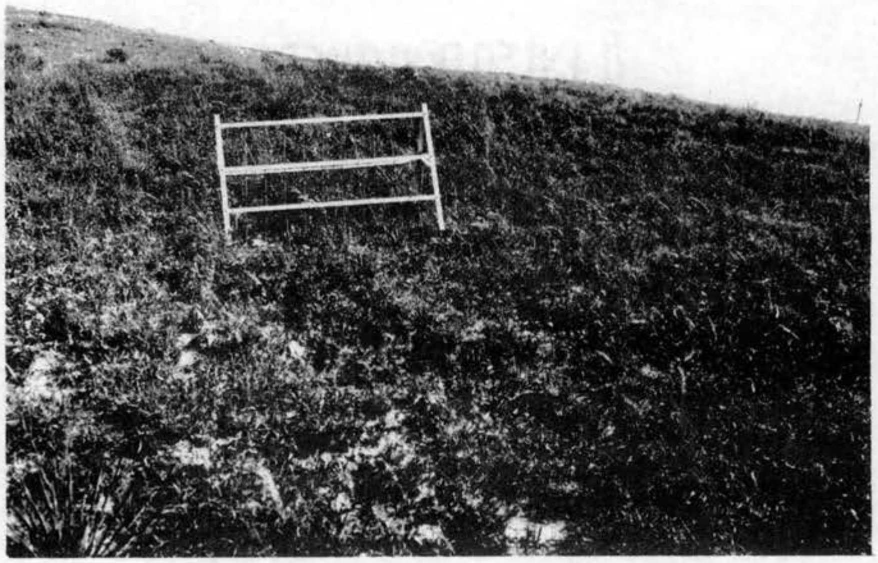


Figure 12. A general view of the vegetation of the shallow soils of the Otero-Pratt complex. Hairy grama is the dominant grass growing on this site.

buffalo (Munroa squarrosa). The invader species did not follow what might be considered the usual pattern. Probably the time of year in which the survey was made contributed to this condition. Most of the annuals were gone, consequently, only the more resistant and unpalatable invader species were present.

The species composition of the grasses found in the survey, illustrating the changes that have occurred due to the intensity of grazing are shown in Table VIII. The changes in the forb composition in the fifteen study areas are shown in Table IX.

Plant Frequency

Buffalograss (Buchloe dactyloides) occurred more frequently than any other grass in all study areas. It was present an average of 48 percent of the time. The frequency of occurrence on good condition range was considerably less than on the fair and poor areas which was 27.9, 54.2, and 60.0 percent respectively.

Sideoats grama (Bouteloua curtipendula) was the second most abundant species (34 percent) over the fifteen areas studied. The distribution and frequency of occurrence decreased from good to poor on the order of 54.4 to 39.7 percent from good to fair and 39.7 to 8.5 percent from fair to poor condition range classes.

Sand dropseed (Sporobolus cryptandrus) had a high frequency of occurrence over all study areas. Distribution did not change much between the three range condition classes. The fair condition area showed this grass to occur about 10 percent more frequently than on

TABLE VIII. CHANGES IN GRASS COMPOSITION DUE TO INTENSITY OF GRAZING.

	Study Areas														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
DECREASER SPECIES	(Percent Species Composition)														
Andropogon scoparius	6.1	0.4	3.2	1.7	0.3		0.1		0.1		.0.3	0.9			1.2
Andropogon halli	1.0	0.1		0.3	0.8							4.3			
Panicum virgatum	0.4									0.2					
Bouteloua curtipendula	35.4	32.2	27.7	33.6	40.6	26.0	25.1	19.7	25.0	15.0	1.7	8.9	2.6	6.4	10.0
Agropyron smithii	0.1														
Calamovilfa gigantea	0.1		0.1	0.2			0.1								
Panicum obtusum								0.7	0.4	0.1					
TOTAL DECREASERS	43.1	32.7	31.0	35.8	41.7	26.0	25.3	20.4	25.5	15.3	2.0	14.1	2.6	6.4	11.2
INCREASER SPECIES															
Bouteloua gracilis	2.9	7.0	5.9	2.1	1.7	7.0	2.2	9.2	2.7	6.0	33.4	44.8	10.0	15.1	16.0
Buchloe dactyloides	15.9	44.5	21.0	20.7	32.7	32.9	34.3	33.3	43.0	61.8	57.7	6.9	67.1	61.2	49.9
Sporobolus cryptandrus	16.9	6.8	11.7	13.9	5.9	18.0	21.5	24.7	7.0	8.6	1.9	17.6	12.6	10.2	16.0
Paspalum stramineum	1.1			1.0								0.9			
Aristida purpurea	0.6		0.1	0.2	0.3	1.3		0.2	0.1	0.1		0.3			
Bouteloua hirsuta	9.5	5.3	15.1	15.2	11.5	9.7	10.7	4.6	17.4	1.2		7.9	2.0	2.2	1.8
Andropogon saccharoides									0.1	1.0	0.1		0.8	0.2	0.2
TOTAL INCREASERS	46.9	63.6	53.8	53.1	52.1	68.9	68.7	72.0	70.3	78.7	93.1	78.4	92.5	88.9	83.9
INVADER SPECIES															
Chloris verticillata	0.4	0.9		2.9	0.6	0.9	0.1		0.6			1.7		0.3	0.3
Schedonnardus paniculatus	0.5	0.1	0.1	0.3	0.3		0.1			0.1				0.1	0.4
Aristida longiseta		0.2	1.9	1.1	1.3	0.2	0.3	0.8	1.2	0.4	0.1	0.8	0.4		1.8
Eragrostis spp.	0.3								0.1						
Tridens pilosus										0.3					0.2
Munroa squarrosa				0.1	0.1									0.2	0.2
TOTAL INVADERS	1.2	1.2	2.0	4.4	2.3	1.1	0.5	0.8	1.9	0.8	0.1	2.5	0.4	0.6	2.9
Range Condition	GOOD					FAIR					POOR				

TABLE IX. CHANGES IN FORB COMPOSITION DUE TO INTENSITY OF GRAZING.

	Study Areas														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PERENNIAL SPECIES	(Percent Species Composition)														
Dalea enneandra				0.2			0.1			0.1					
Aster ericoides	0.1	0.1													
Solidago missouriensis	0.1			0.1		0.2									
Schrankia uncinata					0.1	0.1	0.1			0.2					
Echinacea angustifolia	0.1	0.1	0.1		0.1				0.1	0.1		0.1		0.1	
Psoralea tenuiflora	0.3		0.3	0.2	0.4	0.3	0.4			0.1		0.2		0.1	
Ambrosia psilostachya	0.3	0.5		0.3	0.3	0.6	0.1			0.5	0.4	0.3	1.3	0.6	
Gutierrizia sarothrae	1.7	1.5	1.4	0.3	1.0	0.6	0.2		0.1	0.3	0.6	0.1	1.5	0.4	0.4
Chrysopsis villosa		0.2		0.2	0.5		0.3	0.4				0.3	0.4	0.2	
Haplopappus spinulosis		0.3	0.2	0.2		0.3	0.4	0.3	0.1			0.4	0.3	0.3	0.4
Liatris punctata	0.1		0.2	0.3	0.3	0.3		0.2		0.3	0.3	0.1			
Solanum eleagnifolium	0.3	0.2	0.3	0.2		0.1	0.2				0.2	0.2		0.2	0.1
Cirsium undulatum			0.1		0.1						0.1	0.1		0.1	0.1
TOTAL PERENNIAL SPECIES	3.0	2.9	2.6	2.0	2.8	2.5	1.8	0.9	0.3	1.6	1.6	2.8	3.5	2.0	1.0
ANNUAL SPECIES															
Croton texensis	0.1		0.1	0.3							0.1	0.1	0.1		
Solanum rostratum									0.2			0.1	0.2		
Eriogonum annum	0.6	0.4	0.5	0.6	0.4	0.2	0.2	0.3	0.7	0.1	0.8	0.5	0.4	0.3	1.2
TOTAL ANNUAL SPECIES	0.7	0.4	0.6	0.9	0.4	0.2	0.2	0.3	0.9	0.1	0.9	0.7	0.7	0.3	1.2
TOTAL FORBS	3.7	3.3	3.2	2.9	3.2	2.7	2.0	1.2	1.2	1.7	2.5	3.5	4.2	2.3	2.2
SHRUBS															
Yucca glauca	0.1		0.1	0.1		0.3						0.1		0.1	0.1
Rhus trilobata	0.1		0.1	0.6								0.1			
Opuntia spp.		0.2		0.3	0.8	0.8		0.1	0.1	0.5	1.0		0.4	0.5	0.1
Artemisia filifolia	4.0	3.7	3.6	3.2	2.2	0.2	3.5	5.1	2.0	3.0	3.2	4.2	3.0	3.6	3.0
TOTAL SHRUBS	4.2	3.9	3.8	4.2	3.0	1.3	3.5	5.2	2.1	3.5	4.2	4.4	3.4	4.2	3.2
TOTAL FORBS AND SHRUBS	7.9	7.2	7.0	6.9	6.2	4.0	5.5	6.4	3.3	5.2	6.7	7.9	7.6	6.5	5.4
Range Condition	GOOD					FAIR					POOR				

either the good or poor areas. This strong seeding species maintained the same distribution under heavy grazing in the poor condition class as in the good, occurring 20.1 percent in both classes.

Blue gramagrass (Bouteloua gracilis) increased as grazing pressure increased. The frequency of blue grama in the good and fair condition classes was about the same, however, in the poor condition class blue grama had increased to the extent that it was present in about 40 percent of the quadrats.

The frequency of occurrence of hairy grama (Bouteloua hirsuta) depends to a great extent on the amount of shallow soil present in the Otero-Pratt soil complex. In the undulating portion of the sandy plains range site, hairy grama will be found growing on the steep, shallow soils of the ridges. The frequency of occurrence of this grass on the good and fair condition ranges was practically the same, being 21.8 and 17.4 percent respectively; however, on the poor condition class the frequency dropped to 5.4 percent.

Sand bluestem (Andropogon halli) was found only on the deep soils of the Otero-Pratt soil complex. Its occurrence was seemingly limited to the deep soils, however, the frequency of occurrence was about equal on all condition classes. The vigor and the amount of sand bluestem on the fair and poor condition classes were not equal to the good condition class. Very little difference in the dispersion of this species was noted on any of the range condition classes.

Little bluestem (Andropogon scoparius) is another grass found principally on the deep soils of the Otero-Pratt soils complex. This grass was found on only about one-third of the study areas. Scattered plants would appear on the true Otero soils where some type of disturbance had altered the soil condition. Areas such as old wagon roads, cattle trails, erosive hill sides, or areas of accumulation of sand and silt due to wind erosion were the areas on which scattered plants of little bluestem would be found growing.

Threeawn grasses (Aristida spp.) were present on all of the areas in limited quantities. Frequency of occurrence was between 2 and 3 percent of the quadrats. This species did not show any significant change in frequency between the good, fair, and poor condition classes.

Other desirable grasses with a very low frequency of occurrence were switch grass (Panicum virgatum) western wheatgrass (Agropyron smithii), sand reedgrass (Calamovilfa gigantea), vine mesquite (Panicum obtusum) and sand paspalum (Paspalum stramineum).

Several low value grasses were present in low frequency. Silver bluestem (Andropogon saccharoides) was present in small quantities in the poor condition class. Windmill grass (Schendonnardus paniculatus) had about the same frequency in all three classes.

The average frequency of occurrence for each species on the three condition classes is shown in Table X. A graphical presentation of the average frequency of occurrence of the six most important grasses in the three range condition classes is shown in Figure 13.

Quantity and Cover of Mulch

The total quantity of all detached dead litter and all attached forage was gathered from four study areas: namely, number 1, good range condition; number 9, fair range condition; number 15, poor range

TABLE X. THE AVERAGE FREQUENCY OF OCCURRENCE OF GRASS SPECIES ON THE GOOD, FAIR, AND POOR CONDITION RANGE CLASSES. THE AVERAGES ARE BASED ON 1000 QUADRATS FOR EACH CONDITION CLASS.

Species	Range Condition Class		
	Good	Fair	Poor
DECREASER SPECIES	Percent	Percent	Percent
Andropogon scoparius	2.3	0.4	0.8
Andropogon halli	0.9	0.2	0.7
Panicum virgatum	0.2	0.1	---
Bouteloua curtipendula	54.4	39.7	8.5
Agropyron smithii	0.1	0.1	---
Calamovilfa gigantea	0.3	0.1	---
Panicum obtusum	---	0.2	---
INCREASER SPECIES			
Bouteloua gracilis	6.4	9.9	40.5
Buchloe dactyloides	27.9	54.2	60.0
Sporobolus cryptandrus	20.1	31.1	20.1
Paspalum stramineum	0.9	---	0.5
Aristida purpurea	3.1	2.5	2.0
Bouteloua hirsuta	21.8	17.4	5.4
Andropogon saccharoides	---	0.6	0.5
INVADER SPECIES			
Chloris verticillata	4.3	1.5	0.9
Schedonnardus paniculatus	0.5	0.4	0.04
Aristida longiseta	0.6	0.5	0.3
Eragrostis spp.	0.2	0.1	---
Tridens pilosus	---	0.1	0.1
Munroa squarrosa	---	---	0.1

condition; and the non-grazed study area number 16. Each species was weighed individually and oven dried. The pounds of mulch per acre on the non-grazed area are shown in Table XI. The pounds of mulch on each of the study areas numbers 1, 9, 15, and 16 are shown in Tables XI, XII, XIII, and XIV respectively.

The mulch cover decreased as intensity of use increased. The total quantity of all attached forage and all detached litter was 5633 pounds per acre for the non-grazed area; 2683 pounds per acre for the good condition area; 1664 pounds per acre for the fair and only 491 pounds per acre for the poor condition study area. These results are similar to the results obtained by Rhoades, et al. (1964) in their study of water intake on sandy range land.

The mulch cover on the good condition area is adequate to prevent soil detachment and to increase water intake. According to the limits set forth by Osborn (1950), the mulch cover on the fair and poor condition study areas would not be adequate.

The good condition area has sufficient mulch to retard evaporation and improve the soil as a habitat for soil organisms according to requirements pointed out by Hopkins (1949). The fair and poor condition areas would not be adequate. The ability of the soil to absorb rain water is greatly influenced by the amount of mulch present reported Rhoades et al. (1964). Based upon the results of these studies there is an indication that the good condition area has adequate mulch cover to maintain proper soil temperature, control soil detachment, and adequate water infiltration rates; but the fair and poor condition classes do not.

Figure 13. Average frequency, expressed in percent, of the occurrence of the grasses from 1000 quadrats on good, fair, and poor range condition classes.

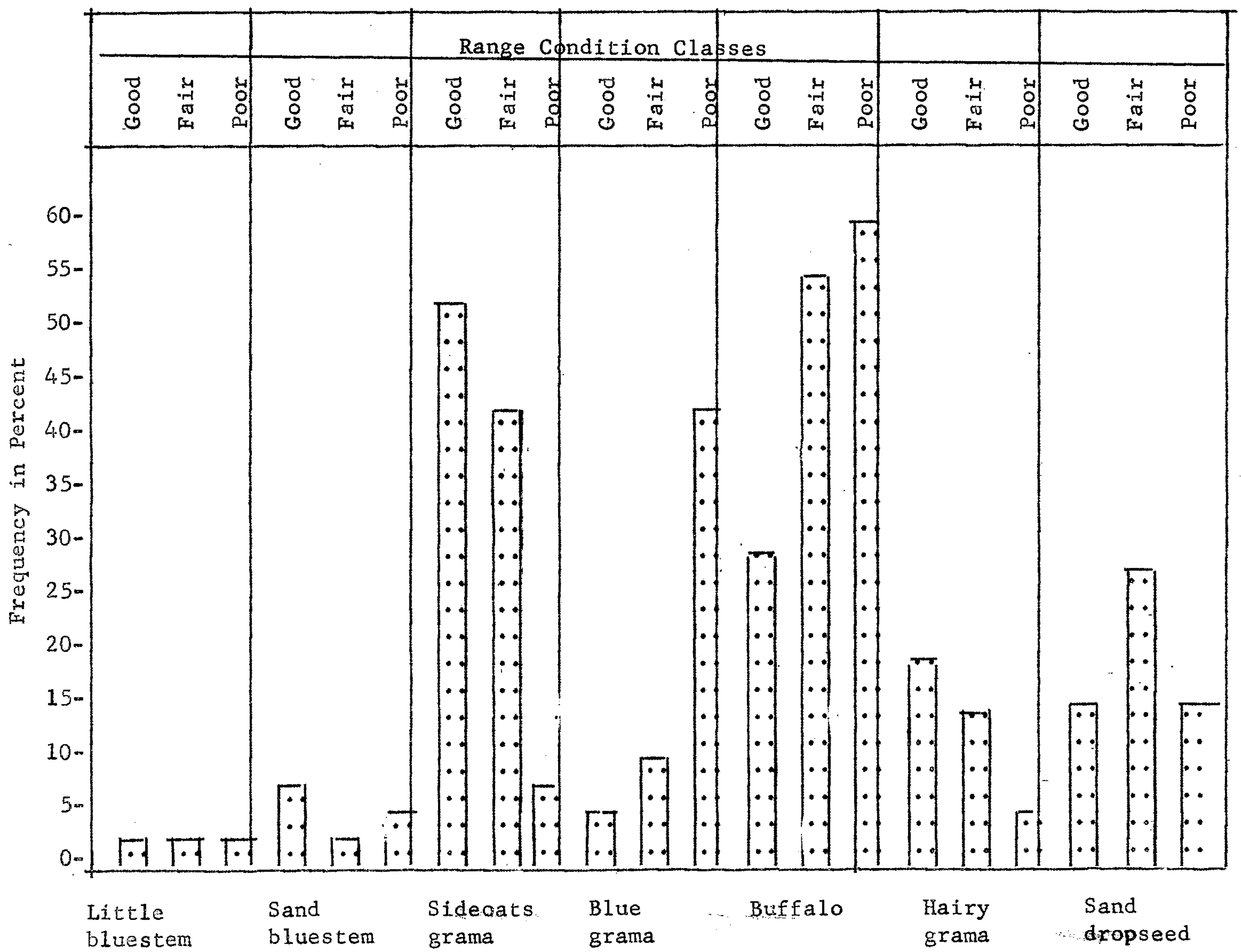


TABLE XI. POUNDS OF OVEN-DRY MULCH PER ACRE FOR THE NON-GRAZED AREA.

Species	Study Area Number 16	
	Oven dry weight pounds per acre	Oven dry weight percent of composition
Buchloe dactyloides	1084	37.0
Bouteloua curtipendula	1395	48.5
Sporobolus cryptandrus	106	4.0
Aster ericoides	149	5.0
Callirhoe involucrata	17	1.0
Haplopappus spinulosus	64	2.0
Psoralea tenuiflora	21	1.0
Lygodesmia juncea	13	.5
Artemisia filifolia	34	1.0
Total oven dry weight (attached material)	2883	100%
Total oven dry weight (unattached material)	2750	
Total mulch cover	5633	

TABLE XII. POUNDS OF OVEN-DRY MULCH PER ACRE FOR THE GOOD CONDITION RANGE.

Species	Study Area Number 1	
	Oven-dry weight pounds per acre	Oven-dry weight percent of composition
Buchloe dactyloides	574	34
Bouteloua gracilis	128	8
Bouteloua curtipendula	319	19
Sporobolus cryptandrus	132	9
Bouteloua hirsuta .	157	10
Aristida spp.	21	1
Liatris punctata	21	1
Callirhoe involucrata	21	1
Gutierrezia sarothrae	34	3
Eriogonum annum	43	1
Lygodesmia juncea	38	1
Chrysopsis villosa	13	1
Artemisia filifolia	182	11
Total oven-dry weight (attached material)	1683	100%
Total oven-dry weight (unattached material	1000	
Total mulch cover	2683	

TABLE XIII. POUNDS OF OVEN-DRY MULCH PER ACRE FOR THE FAIR CONDITION RANGE.

Species	Study Area Number 9	
	Oven dry weight pounds per acre	Oven dry weight percent of composition
Bouteloua curtipendula	425	32
Bouteloua gracilis	85	7
Buchloe dactyloides	527	40
Sporobolus cryptandrus	34	3
Bouteloua hirsuta	170	13
Gutierrezia sarothrae	51	4
Haplopappus spinulosus	17	1
Total oven dry weight (attached material)	1309	100%
Total oven dry weight (unattached material)	355	
Total mulch cover	1664	

TABLE XIV. POUNDS OF OVEN-DRY MULCH PER ACRE FOR THE POOR CONDITION RANGE.

Species	Study Area Number 15	
	Oven dry weight pounds per acre	Oven dry weight percent of composition
Buchloe dactyloides	90.4	27.8
Bouteloua curtipendula	30.2	9.3
Bouteloua gracilis	138.8	42.7
Sporobolus cryptandrus	18.2	5.6
Aristida spp.	6.2	1.9
Artemisia filifolia	41.2	12.7
Total oven dry weight (attached material)	325.0	100%
Total oven dry weight (unattached material)	166.0	
Total mulch cover	491.0	

A good condition range area as shown in Figure 14 has adequate mulch to hold the rainfall where it will do the most good and also reduce soil detachment to a minimum. This area approaches the non-grazed area in every respect and appears to be in condition to produce the maximum amount of forage.

The fair condition area shown in Figure 15 was lacking in mulch cover and indicates that the grass composition and the amounts of the various species are not adequate. This area is showing considerable retrogression and is not in condition to produce the maximum amounts of forage that the site is capable of producing.

The poor condition area is shown in Figure 16. This range is lacking in all the essentials for maximum production. Considerable bare ground is present which will permit soil detachment and loss of rainfall. Retrogression has reached a point, that without adequate management practices, continued deterioration of the range can be expected

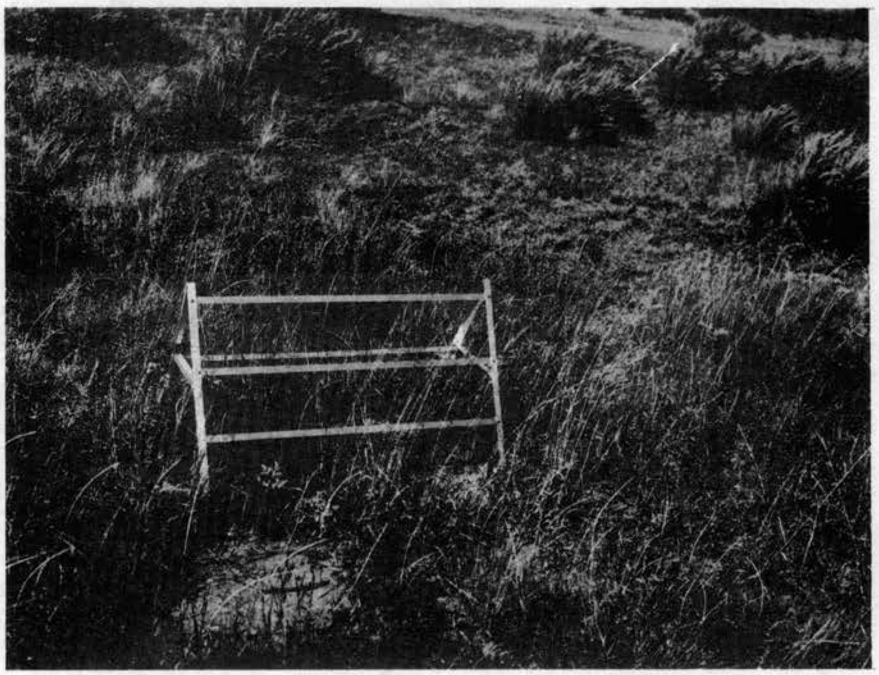


Figure 14. A good condition range. The quantity of vegetation was somewhat similar to that found in the non-grazed area.

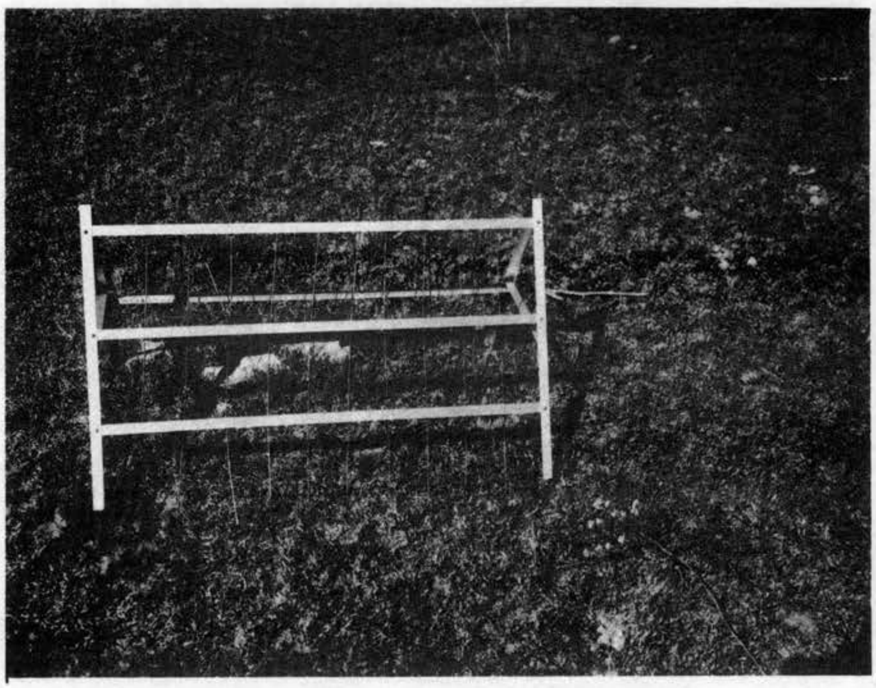


Figure 15. A fair condition range area. The area has been grazed rather evenly; however, a good cover of grass is present with very little open ground showing. Blue gramagrass and buffalograss are the main grasses in this area.

Figure 16. A poor condition range area. Note the abundance of open or bare ground. Not much litter or mulch can be expected from this pasture. Pedestalling of the grasses is evident. Wind and water erosion can be expected to occur on this area.

CHAPTER VI

SUMMARY

A study was made of sandy plains range sites in the high plains of Beaver County, Oklahoma, to determine the pattern of retrogression occurring due to overgrazing, drought, erosion and other disturbances.

In order to show the change in the vegetation from the climax it was necessary to locate and study the vegetation on areas which had not been disturbed. Two such areas, undisturbed for over 50 years, were studied in detail.

Fifteen study areas, currently in use, were analyzed in an effort to show the pattern of retrogression occurring. These fifteen areas were later classified and placed in a range condition class. Three range condition classes, good, fair, and poor were used in this study.

The amount of mulch was determined for one of the non-grazed areas and for one each of the good, fair, and poor condition areas.

The soils of the sandy plains range site are composed of the Otero-Pratt soil complex.

The important findings were:

(1) Retrogression has occurred as evidenced by the reduction of decreaser grasses from 36.8 percent in the good condition range to 7.3 percent in the poor condition range, and by the increase of increaser grasses from 53.9 percent in the good condition range to 87.4 percent in the poor condition range.

(2) The composition of the grass and the amount of mulch on the good condition study areas was comparable to the non-grazed areas, indicating that under proper management a range can be maintained in close proximity to a climax condition.

(3) Sideoats grama was the most abundant decreaser grass in all study areas, comprising 30.5, 33.9, 22.1, and 5.9 percent of the vegetation in the non-grazed, good, fair, and poor condition areas respectively.

(4) Decreaser grasses, mostly sideoats grama, composed 36.8, 22.4, and 7.3 percent of the vegetative composition in the good, fair, and poor condition areas, respectively.

(5) Increaser grasses, mostly blue grama, buffalograss, and sand dropseed composed 53.9, 71.7, and 84.5 percent of the vegetative composition in the good, fair, and poor condition areas, respectively.

(6) Invader grasses were very limited, composing 2.2, 1.0, and 1.3 percent of the vegetative composition in the good, fair, and poor condition areas, respectively.

(7) Average basal cover was 35.2, 41.8, and 34.2 percent for the good, fair, and poor condition areas.

(8) Pounds of mulch for the non-grazed, good, fair, and poor condition areas were 5633, 2683, 1664, and 491 pounds per acre, respectively.

(9) Tall grasses such as sand bluestem and little bluestem were found mainly on the Pratt, Likes, and Lincoln soils of the Otero-Pratt soil complex.

(10) When the tall grasses were found on the Otero soils, some form of disturbance had occurred such as an old road, cattle trail, excavation or an accumulation of sand-silt deposited by wind from an adjacent area.

(11) The average percent of decreaser grasses in the non-grazed area was 30.5 percent.

(12) The average percent of increaser grasses in the non-grazed area was 69.5 percent.

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